



Memorandum

To: *Stephanie Vaughn, EPA Region 2*
Elizabeth Buckrucker, USACE

From: *Frank Tsang and Scott Kirchner (CDM Smith)*

Date: *April 14, 2014*

Subject: *2011-2013 Chemical Water Column Monitoring, Small Volume Split Sampling Data Comparison for the Lower Passaic River Study Area*

At the request of the United State Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE), CDM Federal Programs Corporation (CDM Smith) collected oversight split samples as part of the Lower Passaic River (LPR) Restoration Project remedial investigation conducted by the Cooperating Parties Group (CPG). This memorandum presents the comparison of the EPA oversight team's split sample results to the CPG's sample results and discusses the differences in the data pairs. In this document, samples are referred to as either CPG samples or EPA split samples for clarity.

The split sample comparison consisted of 43 split sample pairs. The following pairs were compared: 27 split sample pairs evaluated for polycyclic aromatic hydrocarbons (PAHs), pesticides and metals (arsenic, barium, chromium, titanium, zinc and methyl mercury); and 43 split sample pairs evaluated for dioxins/furans, polychlorinated biphenyls (PCBs), organic carbon (total organic carbon [TOC], dissolved organic carbon [DOC], particulate organic carbon [POC]), and metals (copper, lead, and mercury). All of the EPA and CPG split sample pairs are comparable except:

- Dioxins/Furans: 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF), octachlorodibenzo-p-dioxin (OCDD), octachlorodibenzofuran (OCDF), total heptachlorinated dibenzo-p-dioxins (total HpCDDs), and total tetrachlorodibenzo-p-dioxins (total TCDDs).
- Pesticides: cis-nonachlor and trans-nonachlor.
- PCBs: 3,3',4,4'-tetrachlorobiphenyl (PCB 77), 3,3',4,4',5-pentachlorobiphenyl (PCB 126), 2,3,3',4,4',5-hexachlorobiphenyl plus 2,3,3',4,4',5'-hexachlorobiphenyl (PCB 156+157), total octachlorobiphenyls, total pentachlorobiphenyls, total tetrachlorobiphenyls, total trichlorobiphenyls, and total PCBs. The total homologs reported by the CPG were consistently lower than those reported in the EPA data set. This low bias may be attributed to the inclusion as in the case of the EPA data, or exclusion as in the case of the CPG data of low level detects (those below the reporting limit or those qualified as estimated maximum potential concentration (EMPC)), in calculating the total homologs.

- PAHs: benz[a]anthracene and benzo[b]fluoranthene.
- Metals: total arsenic, dissolved arsenic, dissolved lead, total zinc, total mercury, and total methyl mercury. The results for total and dissolved mercury and total methyl mercury indicate a high bias in the CPG data. This bias does not appear to be consistent or quantifiable. The results for total and dissolved arsenic indicate a low bias in the CPG. This bias is significant since all EPA results detected above 10 µg/L (roughly half the evaluated data pairs) are notably higher than CPG results by 10 to 40 times. The reason(s) for this variability could not be ascertained from the available information.

Oversight Program

Oversight was conducted in accordance with the CDM Smith 2011 Final Quality Assurance Project Plan (QAPP), Addendum No. 8 Chemical Water Column Monitoring Study/Small Volume Data. Forty-three water split sample pairs were collected from the study area.

Data Comparison Methodology

The CPG and EPA split sample data were evaluated for potential differences by plotting selected analytes listed on Table 1. For each of the following three plots, data are plotted on the figures and evaluated only for the cases where both sample pairs are detected.

- Line Plot: The concentrations measured by both analytical programs for the detected paired samples were plotted against the same axes. The graph depicts the relative magnitudes and patterns of concentrations.
- Bivariate Scatter Plot: CPG sample concentration was plotted as a function of EPA sample concentration for each detected pair. The bivariate scatter plot illustrates the relationship between EPA and CPG data. Also included on the graph is a line which depicts a 1:1 ratio of concentration of EPA and CPG sample. The bivariate plot can be used to identify potential systematic bias when data points fall consistently above or below the 1:1 line.
- Percent Difference Plot: The percent difference (%D) was defined as the difference between concentration for detected data pairs, divided by the concentration of EPA sample (Equation 1).

$$\% D = \frac{(R_{EPA} - R_{CPG})}{(R_{EPA})} (100) \quad (\text{Equation 1})$$

Consequently, a negative %D indicates a CPG result that is higher than the EPA result, while a positive %D indicates a CPG result that is lower than the EPA result. This plot provides a visual indication of the extent of positive and negative differences between the two data pairs. The red dashed lines on the plot correspond to the criteria of 33%D and -50%D. These criteria correspond to 40% relative percent difference (RPD) (CDM Smith's split sample measurement performance criterion), converted to %D values. The term of %D is commonly used when one of the two values is known or accepted, whereas RPD is more commonly used when both values are uncertain. The sample data in this graph was represented with the EPA result as the known value and the CPG result as the unknown value.

In addition to the preparation of data comparison plots, the tests described below were also conducted for CPG and EPA data pairs where both results were detected.

- Average Ratio: The ratios of the CPG results to EPA results were calculated for each sample pair. The average ratio and standard deviation were calculated. An average ratio above one indicates that the CPG results were detected higher than the EPA results, while an average ratio below one indicates that the CPG results were detected lower than the EPA results.
- Percent Difference: The calculated %D values were evaluated against the acceptance criteria of greater than or equal to -50%, or less than or equal to 33% (equivalent to less than or equal to 40% RPD).
- Statistical Test: The statistical tests were performed to calculate *p*-values. The *p*-value is an indicator of the presence of a difference between the data pairs. A *p*-value of less than 0.05 indicates a statistically significant difference between the two data sets.
 - Wilcoxon Signed Rank (WSR) Test: The WSR test was used to calculate *p*-values for all detected sample pairs.
 - Paired Prentice-Wilcoxon (PPW) Test: In addition to the WSR test conducted on the detected data pairs, a modified version of the test, the PPW test, was also conducted to allow inclusion of the left-censored (nondetected) data pairs. The elimination of data pairs containing nondetected values is essentially equivalent to ignoring potentially substantial information contained within these nondetect-containing data pairs, and may lead to biased results. The PPW test relies on survival analysis computations as detailed in O'Brien and Fleming (1987) and is considered the standard test for the case of censored matched pairs (Helsel 2005).

The data comparison plots are depicted in Figures 1 through 48. Results for the three comparison criteria (average ratio, %D, and statistical test) are presented in Table 1. The numbers of split sample pairs are listed for each compound/group along with the number of pairs which had detected results for both samples. The average ratio of results of CPG sample to those of EPA sample results are reported with the standard deviation of the ratios. The %D results are summarized by reporting the percentage of data pairs that exceeded the acceptance criteria (33% and -50%). Also included are the *p*-values calculated by the WSR test and the PPW test.

An overall evaluation of the split sample data is based on the result of the three comparison criteria, where each compound has a rating of "Same" or "Different". The data pairs are considered comparable or "Same" if at least two of the three criteria are met. The comparison criteria for each compound are listed below.

- Average Ratio: Average ratio of CPG to EPA results within 0.70 to 1.30.
- Percent Difference: Less than 16% of the data pairs exceed the acceptance criterion of -50% to 33%.
- Statistical Test (WSR Test and PPW Test): *p*-Values greater than or equal to 0.05 are within acceptance limits, indicating there is no significant statistical difference between the data sets.

When WSR test and PPW test draw different conclusions, the conclusions of PPW test would be used by including nondetects since PPW test has more power to discern the differences between datasets.

- Observed bias: The observed bias of CPG results compared to EPA results was assigned based on a review of the three plots for each compound. A bias is observed when a set of samples shows a trend of higher or lower concentrations on the line plot, consistently falling above or below the one-to-one line on the bivariate plot, and falling above or below the +/-50 percent difference criteria on the percent differences plot. It must be understood that this evaluation is a qualitative observation and is not statistically driven.

Results of data comparison of CPG and EPA split samples are summarized below and presented in Table 1 and Figures 1 through 48.

Dioxins/Furans

All six evaluated dioxins/furans were found to be different between the two datasets (Table 1). For all of them, %D criterion was not met, and *p*-values of PPW test were less than 0.05, indicating statistically significant differences. Although most of them had average ratios within the acceptance criterion (0.70 to 1.30), 2,3,7,8-TCDD and total TCDDs had much higher average ratios. Marked discrepancies were found on 2,3,7,8-TCDD. The CPG result for 11A-CE04-TTR1-AS was 81 times the EPA result. However, the EPA results for 12B-CE02-TTR2-BS, 12B-CE04-TTR1-AS, and 12G-CE01-T102-BS were notably greater than CPG results, respectively, by 14, 47 and 202 times. If those pairs were excluded, the average ratio and standard deviation would drop from 3.68 ± 15.38 to 0.81 ± 0.37 which would be within the acceptable range. Also, the CPG result for total TCDDs on 11A-CE04-TTR1-AS was 60 times higher than the EPA result. If this pair was excluded, the average ratio and standard deviation would drop from 6.21 ± 17.21 to 1.25 ± 0.52 , which would be also within the acceptable range.

Pesticides

The data pairs for all nine evaluated pesticide compounds were comparable, except cis-nonachlor and trans-nonachlor. All average ratios were within the acceptance criterion (0.70 to 1.30), ranging from 0.88 to 1.09. 4,4'-DDT, cis-nonachlor and trans-nonachlor failed to meet %D criterion. Although five (alpha-chlordane, dieldrin, heptachlor epoxide, cis-nonachlor and trans-nonachlor) of the nine pesticide compounds had *p*-values less than 0.05 based on PPW test, only cis-nonachlor and trans-nonachlor were considered different overall.

Polychlorinated Biphenyls

Among the eleven PCB parameters evaluated by the three comparison criteria, eight parameters were found to be different. All the average ratios of CPG to EPA results were below 1, indicating the CPG results were lower than EPA results overall, and Figures 16 through 26 also show the predominant low bias of CPG results relative to EPA results. However, only total octachlorobiphenyls had an average ratio (0.67 ± 0.22) slightly below the lower limit of the criterion (0.70 to 1.30). All the *p*-values calculated by the PPW test were less than 0.01, indicating statistically significant differences for all the PCB parameters.

PCB 77, PCB 126, PCB 156+157, total octachlorobiphenyls, total pentachlorobiphenyls, total tetrachlorobiphenyls, total trichlorobiphenyls and total PCBs were the eight PCBs that failed to meet %D criterion. They were considered different in data pairs overall, since at least two of the three comparison criteria were not met.

Polycyclic Aromatic Hydrocarbons

Of the five evaluated PAH compounds, benzo[a]anthracene and benzo[b]fluoranthene were considered different in data pairs. Although all the average ratios for all the five PAH compounds were within the criterion, none of PAH compounds met %D criterion. Benzo[a]anthracene and benzo[b]fluoranthene were found statistically different in EPA and CPG data pairs according to the PPW test.

Metals

Among 14 evaluated metals, dissolved arsenic, lead, and mercury; and total arsenic, zinc, mercury, and methyl mercury were found to be different between CPG and EPA results, due to not meeting either %D criterion or PPW test criterion. The average ratios for all the metal were within the criterion, except dissolved arsenic and mercury, and total mercury, and methyl mercury. Total arsenic and dissolved arsenic had average ratios equal to or less than the lower limit of the criterion (0.70), indicating CPG results were lower than EPA results overall; whereas mercury, dissolved mercury and methyl mercury had average ratios greater than upper limit of the criterion (1.30), indicating CPG results were higher than EPA results overall. Both total and dissolved arsenic had 9 EPA results notably higher than CPG results by 7 to 46 times in 20 and 24 detected pairs; while 4 mercury and 2 dissolved mercury CPG results were 4 to 9 times the EPA results. Besides those metals mentioned, dissolved chromium, and total chromium and titanium did not meet %D criterion, and the PPW test discerned the differences between the two datasets for total copper, lead, and zinc and dissolved lead.

Organic Carbons

All organic carbons results were comparable for the two data pairs. The majority of detections were within %D criteria, except DOC. POC was found to be statistically different in EPA and CPG data pairs according to the WSR and PPW test.

Attachments

Table 1 - 2011-2013 Chemical Water Column Monitoring,
Small Volume Split Sampling Data Comparison Summary

Figures 1 through 48: Statistical Plots

- a. Line Plots
- b. Bivariate Scatter Plots
- c. Percent Differences Plots

- Figures 1 through 6: Plots of Dioxin/Furan Concentrations
- Figures 7 through 15: Plots of Pesticide Concentrations
- Figures 16 through 26: Plots of Polychlorinated Biphenyl Concentrations
- Figures 27 through 31: Plots of Polycyclic Aromatic Hydrocarbon Concentrations
- Figures 32 through 45: Plots of Metal Concentrations
- Figures 46 to 48: Plots of Organic Carbon Concentrations

References

- CDM Smith. 2011. Final Quality Assurance Project Plan (QAPP), Addendum No. 8 Chemical Water Column Monitoring Study/Small Volume Data
- Helsel, D.R. 2005. Nondetects and Data Analysis: Statistics for Censored Environmental Data. Wiley-Interscience.
- O'Brien, P.C. and T.R. Fleming. 1987. A Paired Prentice-Wilcoxon Test for Censored Paired Data. Biometrics 43: 169-180.

Table 1 2011-2013 Chemical Water Column Monitoring, Small Volume Split Sampling Data Comparison Summary

Parameter	Number of Split Sample Pairs	Number of Split Sample Pairs with Detected Concentrations	Comparison Criteria				Overall Split Sample Comparison (Same or Different) ⁽⁶⁾	Observed Bias CPG to EPA (None, High or Low) ⁽⁷⁾	
			Average Ratio of CPG to EPA (for detected pairs) ⁽¹⁾	Percent Difference (for detected pairs) ⁽²⁾	p-value				
			Wilcoxon Signed Rank test ⁽³⁾	Paired Prentice Wilcoxon test ⁽⁴⁾	Statistical Difference (Yes or No) ⁽⁵⁾				
Dioxins/Furans									
2,3,7,8-TCDD	43	27	3.68±15.38	52% Outside Criteria	0.019	<0.001	Yes	Different	None
2,3,7,8-TCDF	43	7	1.28±0.6	29% Outside Criteria	0.447	0.006	Yes	Different	None
OCDD	43	39	0.79±0.4	38% Outside Criteria	0.005	0.001	Yes	Different	None
OCDF	43	29	1.03±0.56	31% Outside Criteria	0.381	0.009	Yes	Different	None
Total HpCDDs	43	35	0.88±0.52	40% Outside Criteria	0.007	0.002	Yes	Different	None
Total TCDDs	43	12	6.21±17.21	42% Outside Criteria	0.170	<0.001	Yes	Different	None
Pesticides									
alpha-Chlordane	27	26	0.88±0.2	4% Outside Criteria	0.007	0.006	Yes	Same	None
2,4'-DDD	27	23	0.98±0.33	4% Outside Criteria	0.107	0.247	No	Same	None
4,4'-DDD	27	25	0.9±0.32	8% Outside Criteria	0.001	0.059	No	Same	None
4,4'-DDE	27	24	0.92±0.28	4% Outside Criteria	0.104	0.082	No	Same	None
4,4'-DDT	27	20	1.03±0.42	30% Outside Criteria	0.587	0.922	No	Same	None
Dieldrin	27	23	0.94±0.13	Within Criteria	0.013	0.009	Yes	Same	None
Heptachlor epoxide	27	27	0.92±0.28	11% Outside Criteria	0.001	0.004	Yes	Same	None
cis-Nonachlor	27	23	1.09±0.3	17% Outside Criteria	0.236	0.022	Yes	Different	None
trans-Nonachlor	27	25	0.88±0.28	28% Outside Criteria	0.027	0.010	Yes	Different	None
Polychlorinated Biphenyls (PCBs)									
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	43	38	0.74±0.31	61% Outside Criteria	<0.001	<0.001	Yes	Different	Low
2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)	43	40	0.81±0.21	13% Outside Criteria	<0.001	<0.001	Yes	Same	None
2,3',4,4',5-Pentachlorobiphenyl (PCB 118)	43	40	0.86±0.18	10% Outside Criteria	<0.001	<0.001	Yes	Same	None
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	43	18	0.98±0.66	39% Outside Criteria	0.349	0.005	Yes	Different	None
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156) + 2,3,3',4,4',5-Hexachlorobiphenyl (PCB 157)	43	39	0.78±0.15	18% Outside Criteria	<0.001	<0.001	Yes	Different	Low
Total Hexachlorobiphenyls	43	43	0.83±0.22	12% Outside Criteria	<0.001	<0.001	Yes	Same	None
Total Octachlorobiphenyls	43	42	0.67±0.22	50% Outside Criteria	<0.001	<0.001	Yes	Different	Low
Total Pentachlorobiphenyls	43	43	0.76±0.21	26% Outside Criteria	<0.001	<0.001	Yes	Different	Low
Total Tetrachlorobiphenyls	43	41	0.76±0.21	34% Outside Criteria	<0.001	<0.001	Yes	Different	Low
Total Trichlorobiphenyls	43	41	0.81±0.22	17% Outside Criteria	<0.001	<0.001	Yes	Different	None
Total PCBs	43	43	0.75±0.22	21% Outside Criteria	<0.001	<0.001	Yes	Different	Low
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	27	26	0.88±0.36	38% Outside Criteria	0.003	0.009	Yes	Different	None
Benzo[a]pyrene	27	23	0.91±0.32	30% Outside Criteria	0.020	0.153	No	Same	None
Chrysene	27	25	1.01±0.35	20% Outside Criteria	0.106	0.837	No	Same	None
Benzo[b]fluoranthene	27	24	1.24±0.44	21% Outside Criteria	0.539	0.021	Yes	Different	None
Indeno[1,2,3-cd]pyrene	27	25	0.93±0.39	44% Outside Criteria	0.034	0.096	No	Same	None
Metals									
Total Arsenic	27	24	0.7±0.56	50% Outside Criteria	0.025	0.008	Yes	Different	Low
Dissolved Arsenic	27	20	0.63±0.58	50% Outside Criteria	0.024	0.022	Yes	Different	Low
Total Barium	27	27	1.01±0.05	Within Criteria	0.657	0.469	No	Same	None
Total Chromium	27	18	0.92±0.32	17% Outside Criteria	0.231	0.167	No	Same	None
Dissolved Chromium	27	13	0.9±0.4	31% Outside Criteria	0.529	0.357	No	Same	None
Total Copper	43	43	0.91±0.15	5% Outside Criteria	<0.001	0.003	Yes	Same	None
Total Lead	43	39	0.9±0.19	5% Outside Criteria	<0.001	0.001	Yes	Same	None
Dissolved Lead	43	27	0.86±0.23	22% Outside Criteria	0.007	0.012	Yes	Different	None
Total Titanium	27	16	0.98±0.38	38% Outside Criteria	0.650	0.289	No	Same	None
Total Zinc	27	24	0.89±0.25	17% Outside Criteria	0.001	0.019	Yes	Different	None
Total Mercury	43	43	1.98±1.81	42% Outside Criteria	<0.001	<0.001	Yes	Different	High
Dissolved Mercury	43	37	1.65±0.95	51% Outside Criteria	<0.001	<0.001	Yes	Different	High
Total Methyl Mercury	27	23	1.46±0.81	30% Outside Criteria	0.001	0.003	Yes	Different	High
Dissolved Methyl Mercury	27	6	1.06±0.21	Within Criteria	0.675	0.415	No	Same	None
Organic Carbons									
Total Organic Carbon	43	32	1.08±0.55	9% Outside Criteria	0.059	0.570	No	Same	None
Dissolved Organic Carbon	43	32	1.09±0.68	19% Outside Criteria	0.155	0.583	No	Same	None
Particulate Organic Carbon	43	38	1.11±0.21	5% Outside Criteria	0.003	0.007	Yes	Same	None

Results outside acceptance criteria are bolded.

Notes:

- (1) Average ratio (criteria: 0.70-1.30) with standard deviation .
 (2) Percent difference criteria: no more than 16% of split samples outside of -50 to 33 percent difference.
 (3) Wilcoxon Signed Rank test was employed at significance level (p) of 0.05.
 (4) Paired Prentice Wilcoxon test was employed at significance level (p) of 0.05.
 (5) Statistical difference was based on both tests when they drew the same conclusion.
 Otherwise, it was based on Paired Prentice Wilcoxon test, which had more power to discern the difference.
 (6) If there are at least two of the three criteria (average ratio, percent different and statistical difference) met,
 the overall split sample comparison would be labeled "same". Otherwise, it would be "different".
 (7) Observed bias assigned based on visual observation of statistical plots for consistent high or low of CPG versus EPA results.

Abbreviations:

- CPG = Cooperating Parties Group
 EPA = United States Environmental Protection Agency
 2,4'-DDD = 2,4'-dichlorodiphenylchloroethane
 4,4'-DDD = 4,4'-dichlorodiphenylchloroethane
 4,4'-DDE = 4,4'-dichlorodiphenylchloroethylene
 4,4'-DDT = 4,4'-dichlorodiphenyltrichloroethane
 2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
 2,3,7,8-TCDF = 2,3,7,8-tetrachlorodibenzofuran
 OCDD = octachlorodibenzo-p-dioxin
 OCDF = octachlorodibenzofuran
 Total HpCDDs = total heptachlorodibenzo-p-dioxin
 Total TCDD = total tetrachlorodibenzo-p-dioxin

Figure 1a: Line Plot of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Concentrations

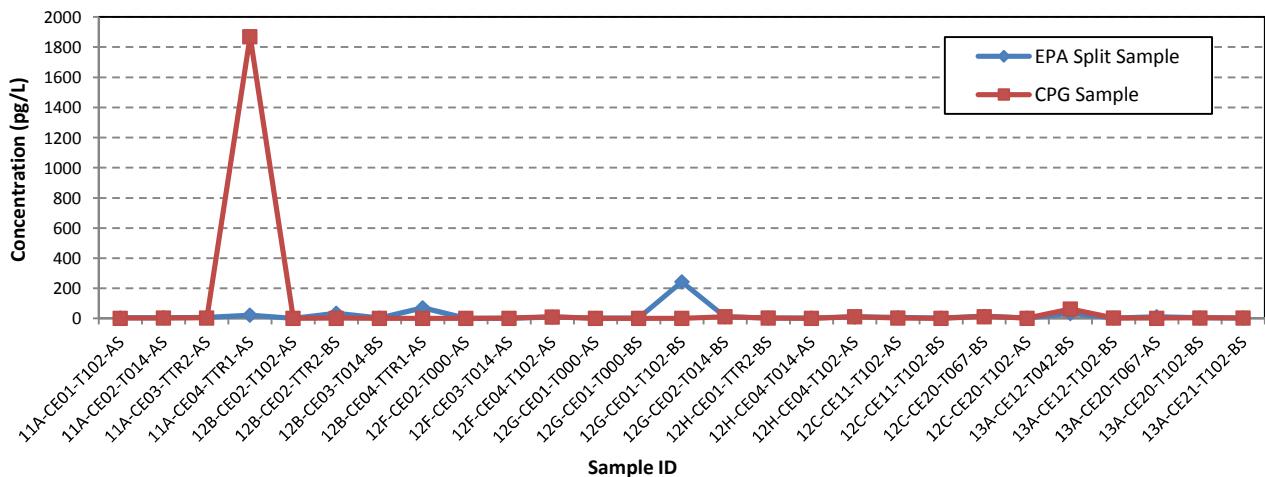


Figure1b: Bivariate Plot of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Concentrations

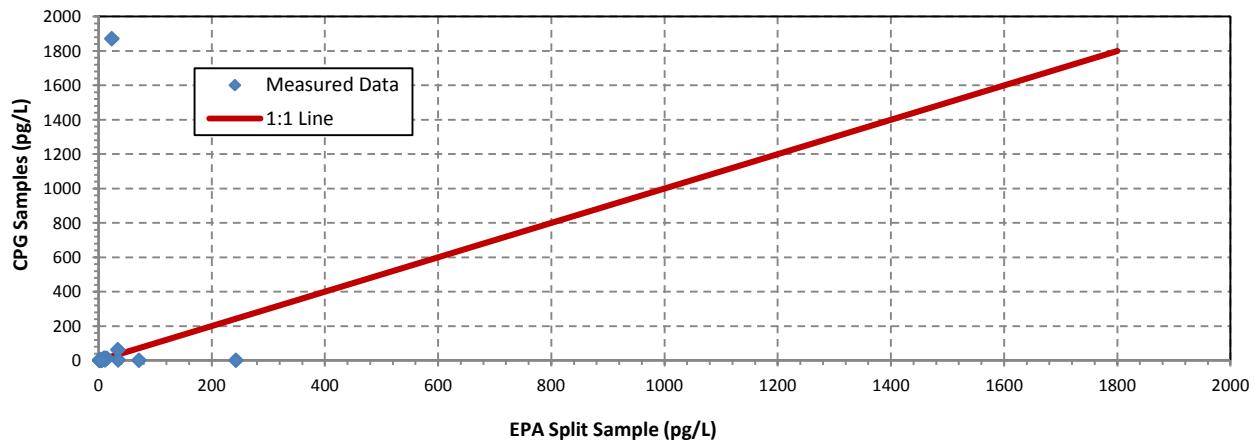
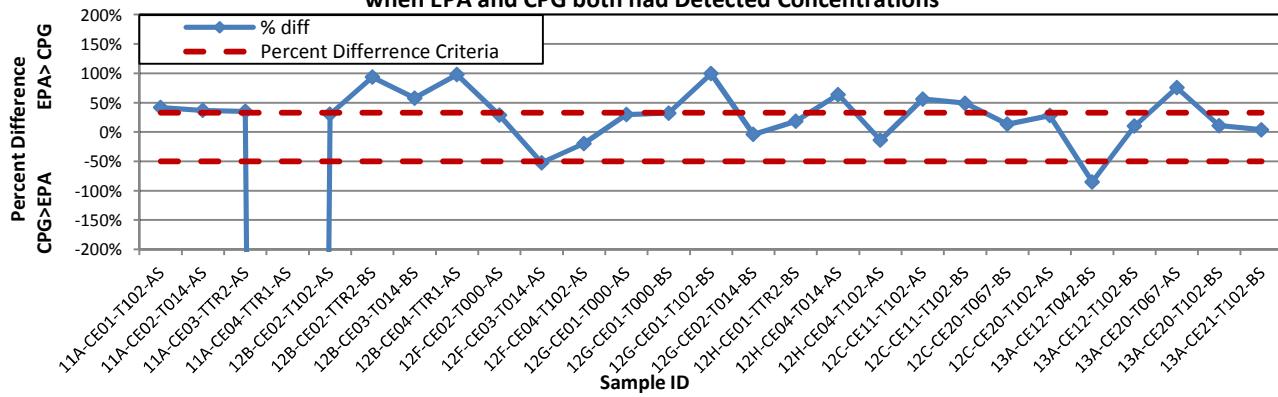


Figure 1c: Line Plot of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Concentrations

Figure 1

Figure 2a: Line Plot of 2,3,7,8-Tetrachlorodibenzofuran Concentrations

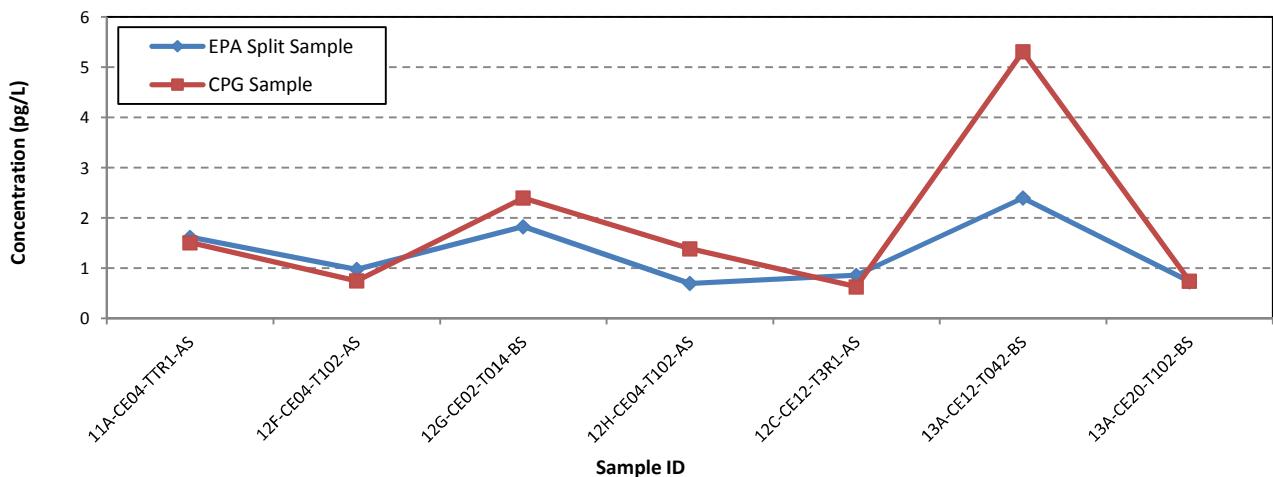


Figure 2b: Bivariate Plot of 2,3,7,8-Tetrachlorodibenzofuran Concentrations

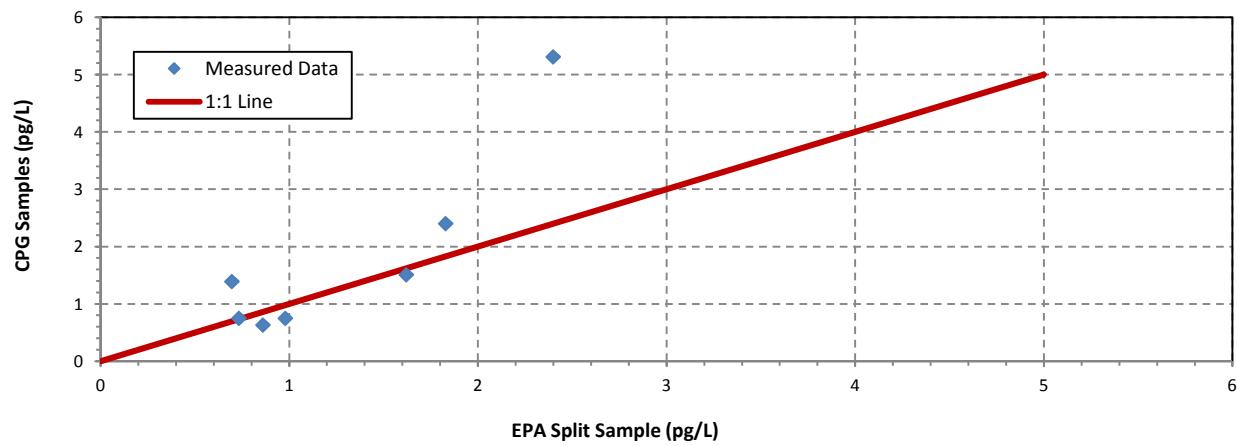


Figure 2c: Line Plot of 2,3,7,8-Tetrachlorodibenzofuran Percent Differences when EPA and CPG both had Detected Concentrations

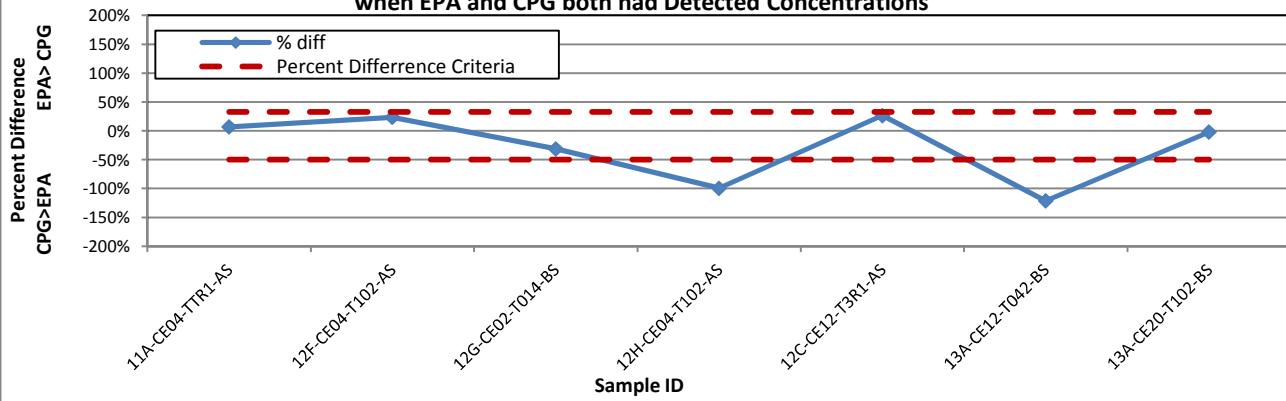


Figure 3a: Line Plot of Octachlorodibenzo-p-dioxin Concentrations

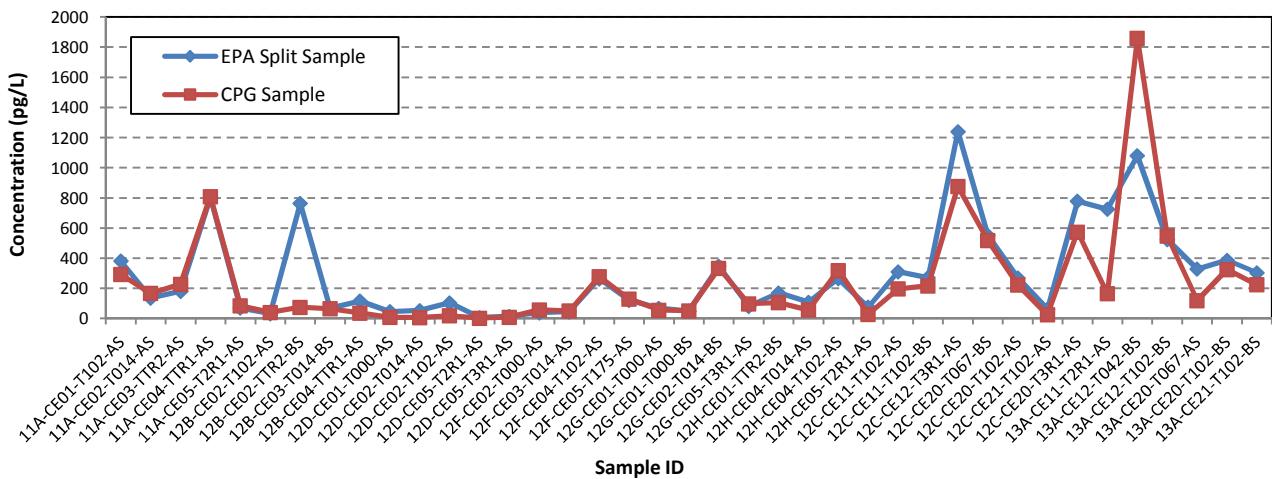


Figure 3b: Bivariate Plot of Octachlorodibenzo-p-dioxin Concentrations

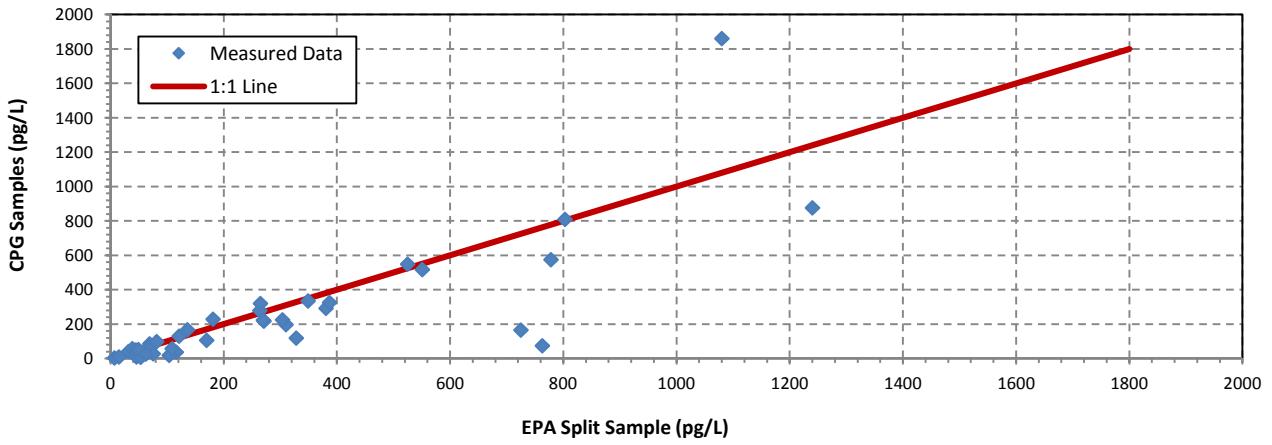


Figure 3c: Line Plot of Octachlorodibenzo-p-dioxin Percent Differences when EPA and CPG both had Detected Concentrations

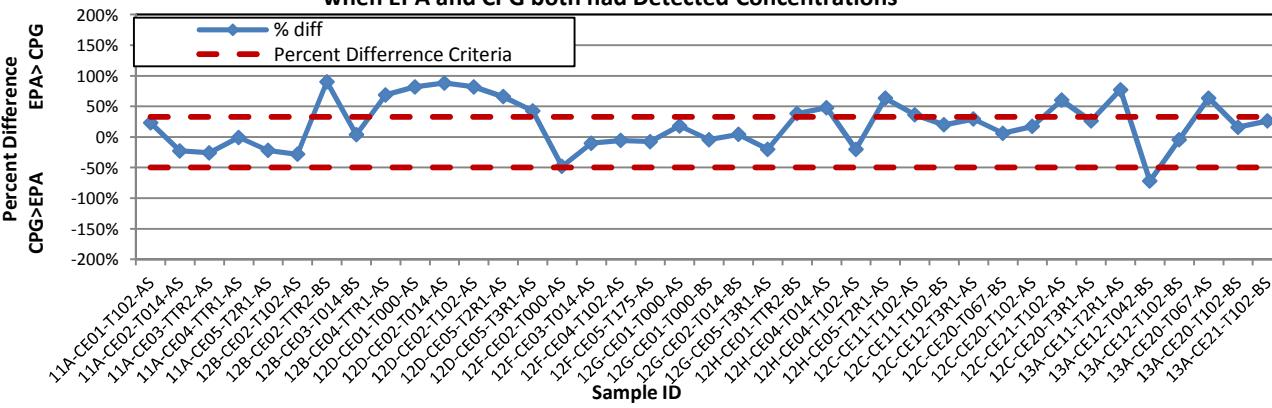


Figure 4a: Line Plot of Octachlorodibenzofuran Concentrations

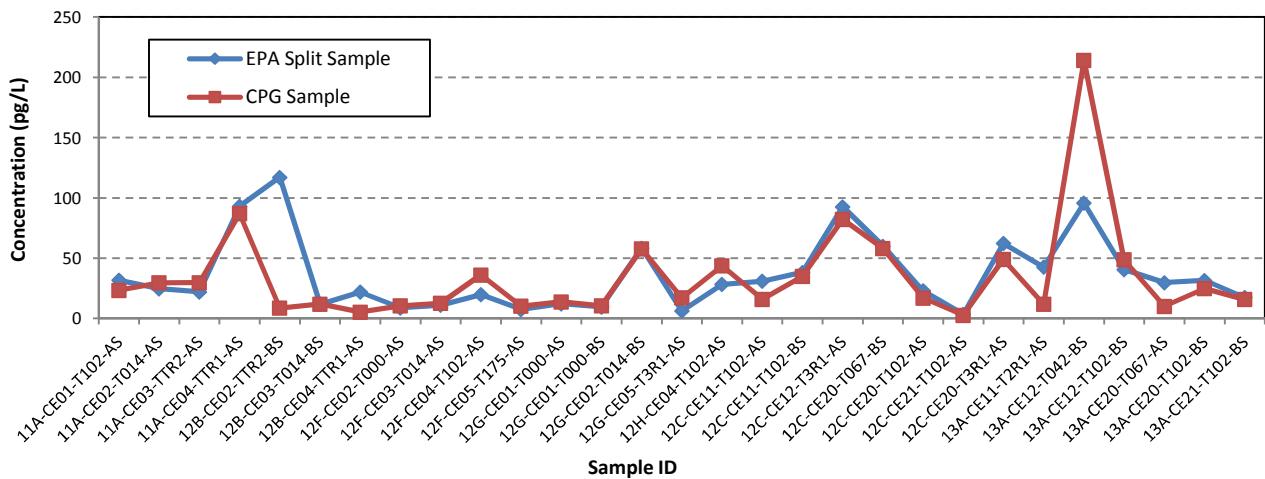


Figure 4b: Bivariate Plot of Octachlorodibenzofuran Concentrations

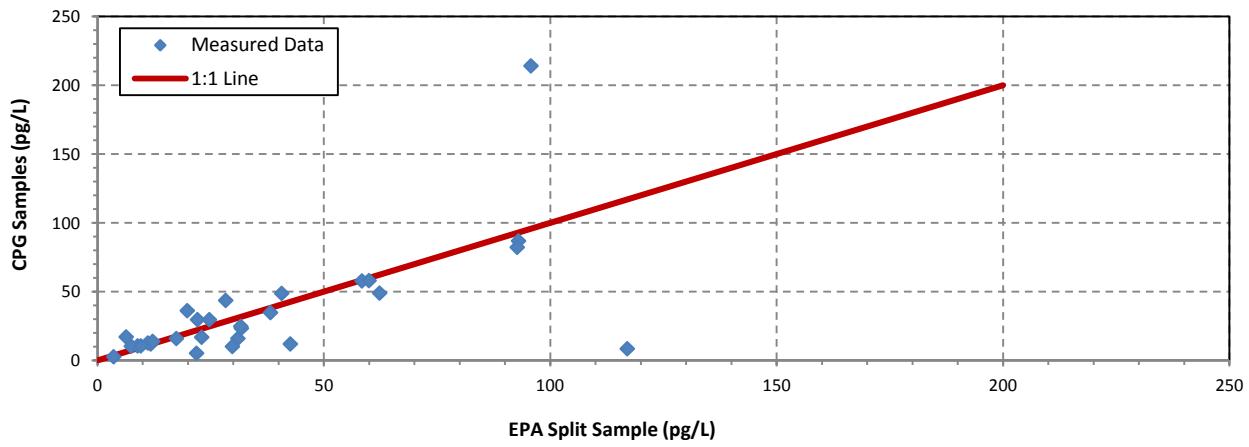


Figure 4c: Line Plot of Octachlorodibenzofuran Percent Differences when EPA and CPG both had Detected Concentrations

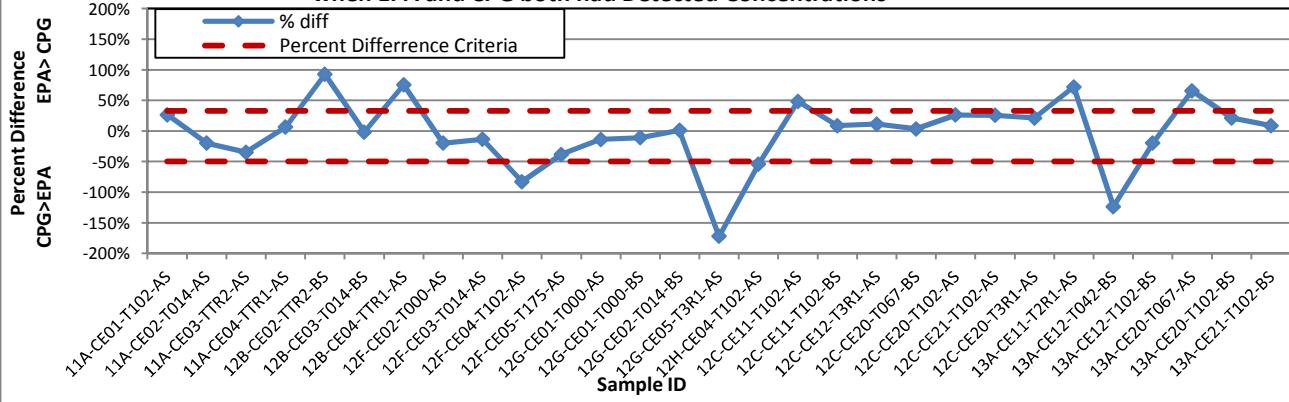


Figure 5a: Line Plot of Heptachlorinated Dibenzo-p-dioxins, (Total) Concentrations

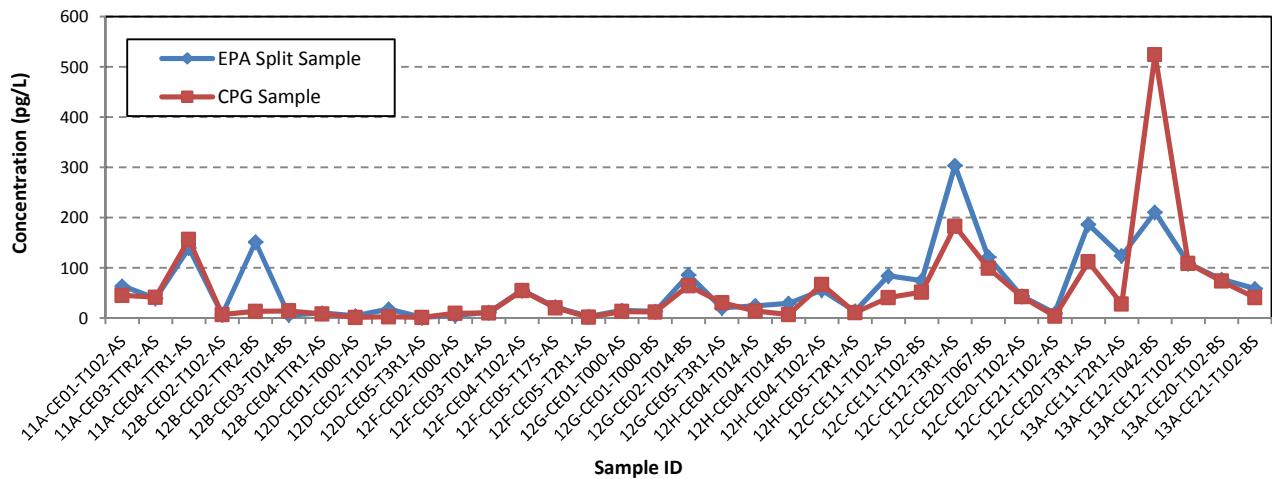


Figure 5b: Bivariate Plot of Heptachlorinated Dibenzo-p-dioxins, (Total) Concentrations

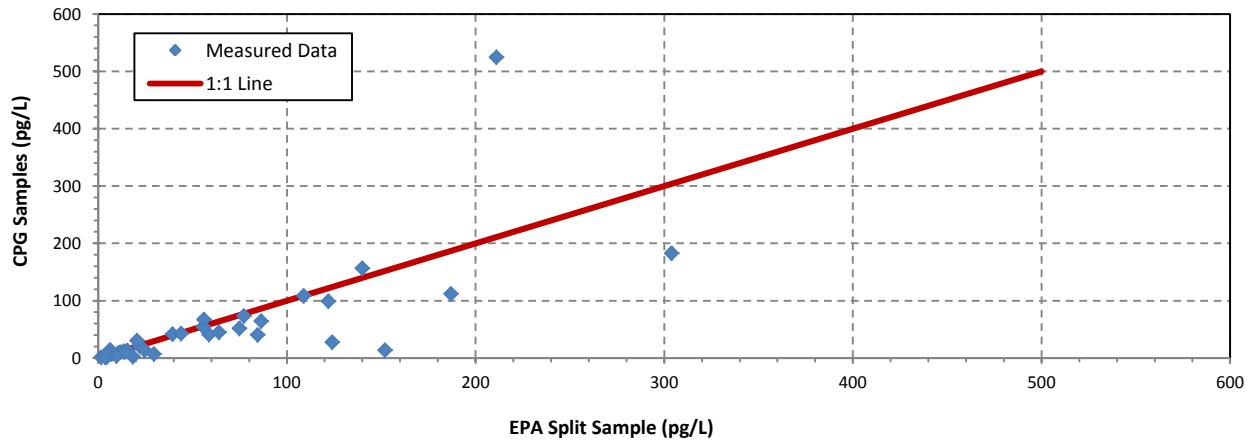
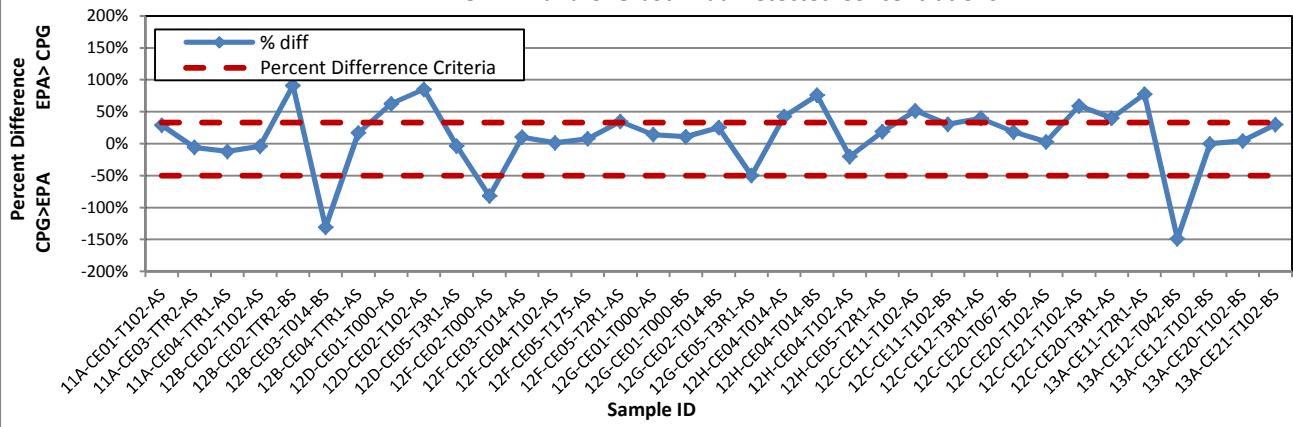


Figure 5c: Line Plot of Heptachlorinated Dibenzo-p-dioxins, (Total) Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Heptachlorinated Dibenzo-p-dioxins, (Total) Concentrations

Figure 5

pg/L - picogram per liter

Figure 6a: Line Plot of Tetrachlorinated Dibenzo-p-dioxins, (Total) Concentrations

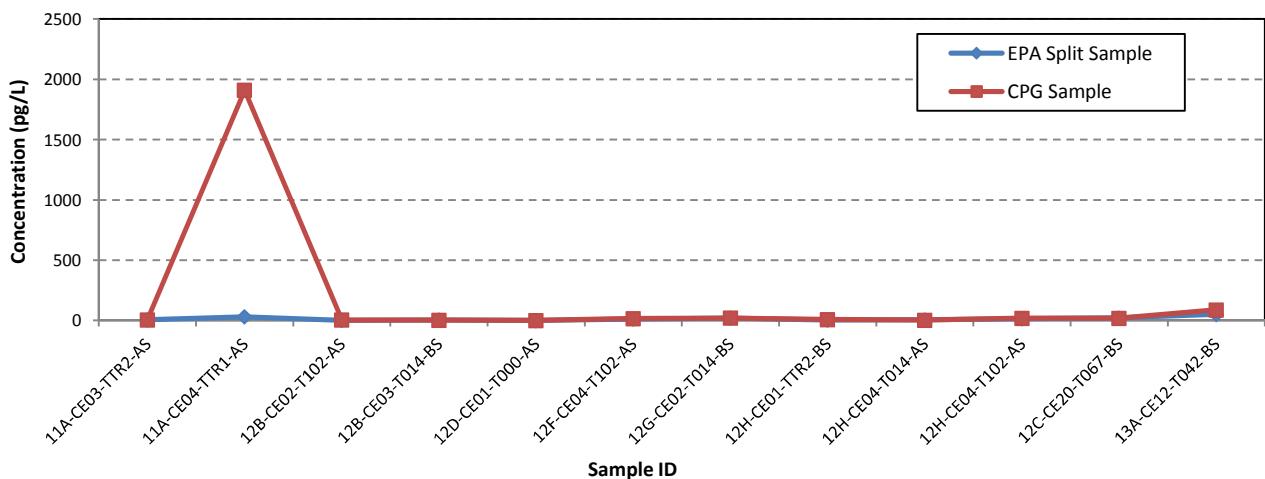


Figure 6b: Bivariate Plot of Tetrachlorinated Dibenzo-p-dioxins, (Total) Concentrations

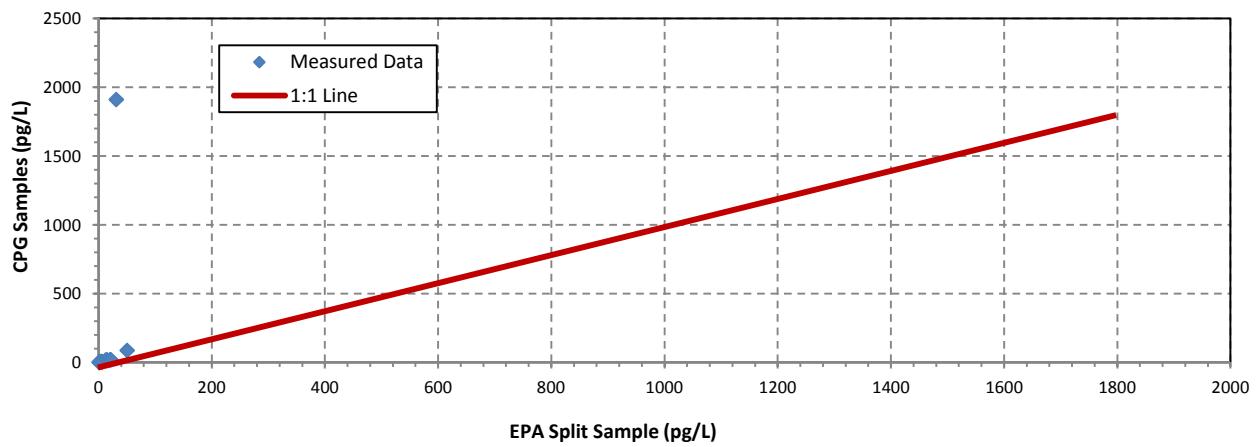
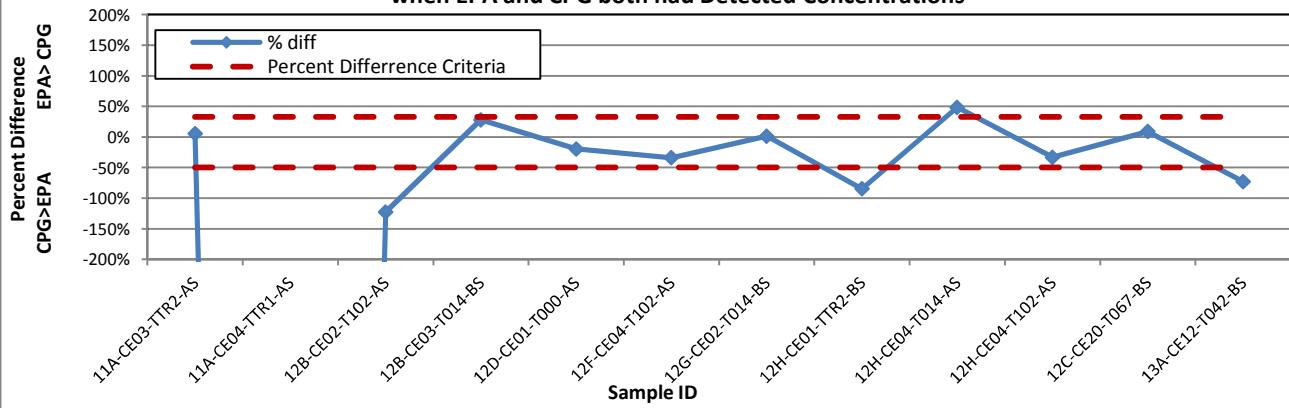


Figure 6c: Line Plot of Tetrachlorinated Dibenzo-p-dioxins, (Total) Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Tetrachlorinated Dibenzo-p-dioxins, (Total) Concentrations

Figure 6

pg/L - picogram per liter

Figure 7a: Line Plot of alpha-Chlordane Concentrations

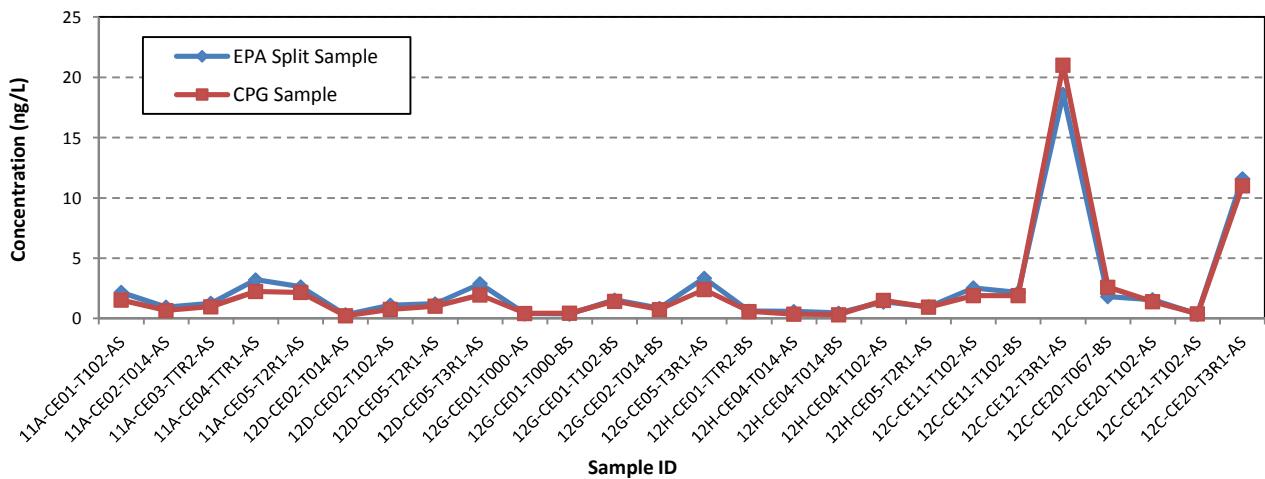


Figure 7b: Bivariate Plot of alpha-Chlordane Concentrations

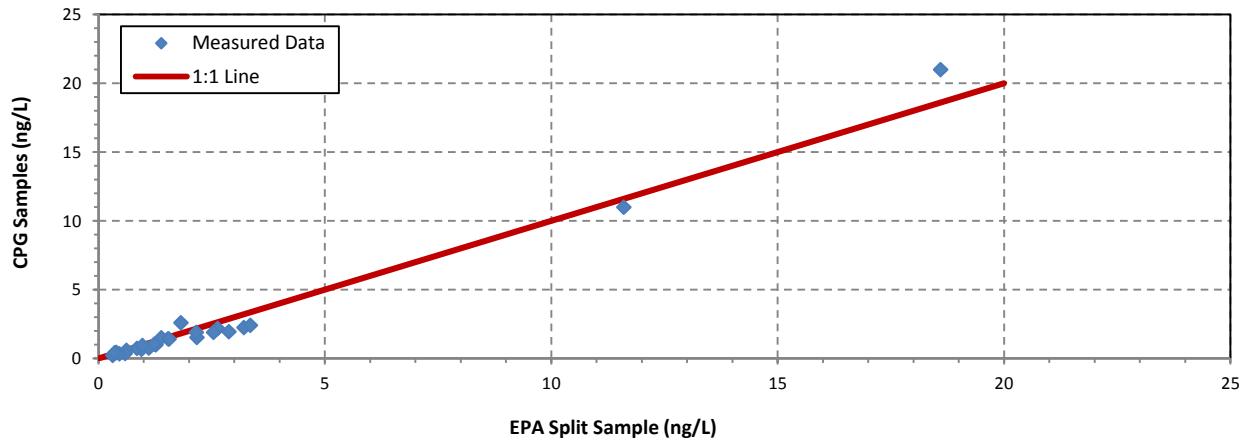
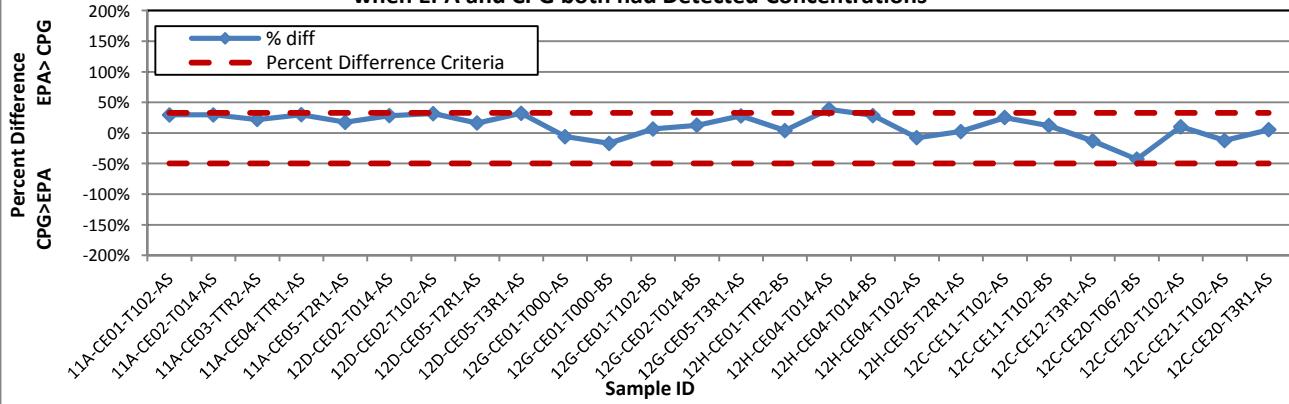


Figure 7c: Line Plot of alpha-Chlordane Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of alpha-Chlordane Concentrations

Figure 7

ng/L - nanogram per liter

Figure 8a: Line Plot of 2,4'-DDD Concentrations

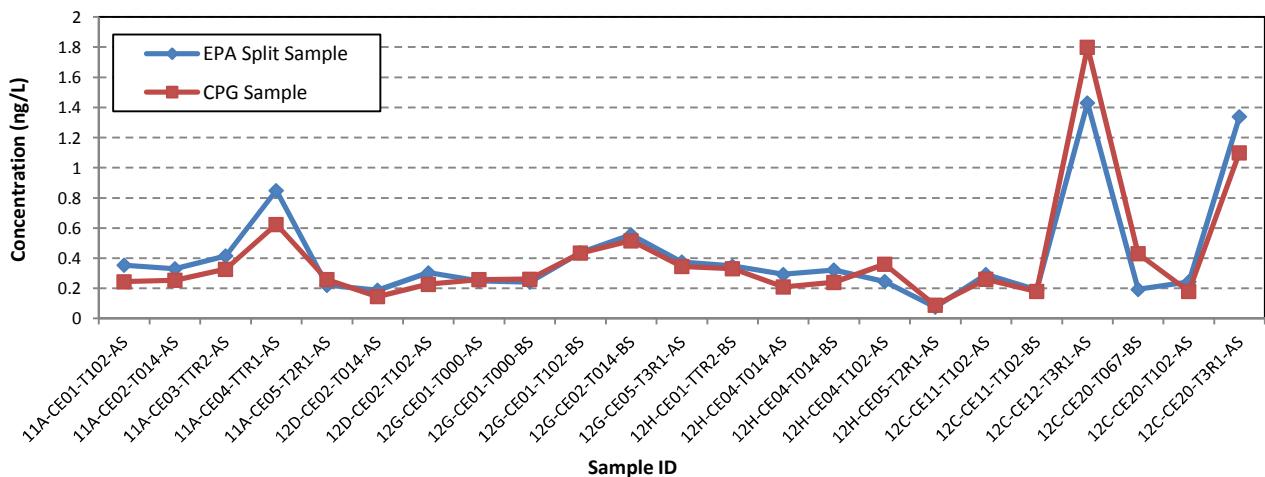


Figure 8b: Bivariate Plot of 2,4'-DDD Concentrations

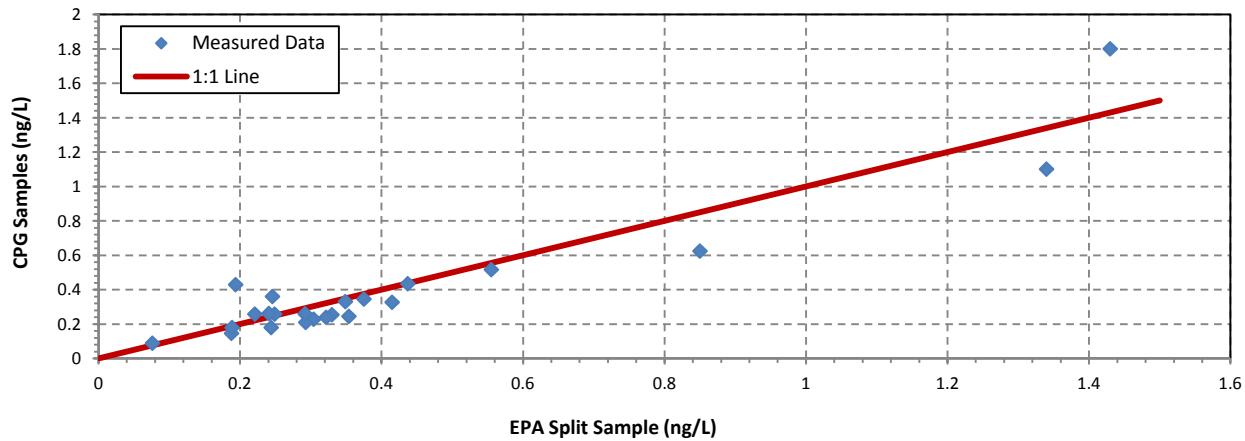
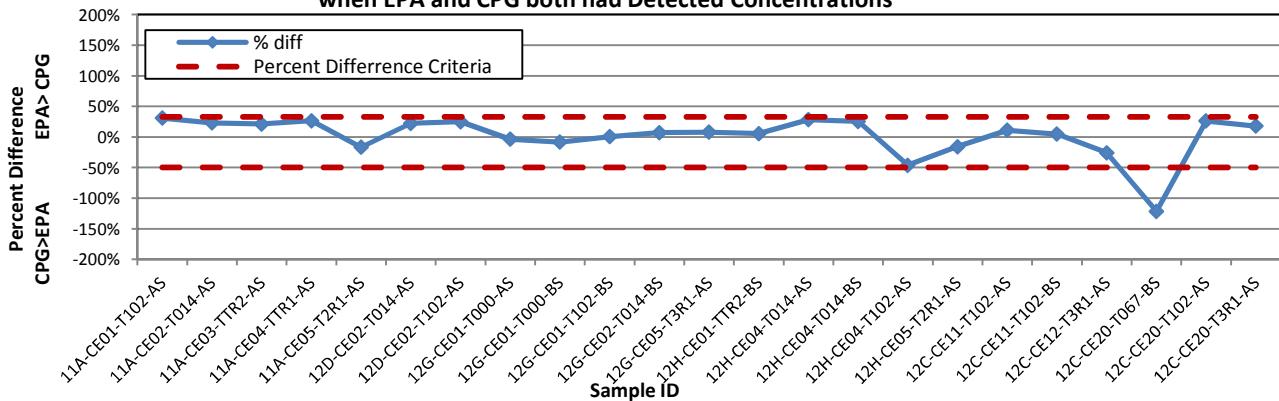


Figure 8c: Line Plot of 2,4'-DDD Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 2,4'-DDD Concentrations

Figure 8

ng/L - nanogram per liter

Figure 9a: Line Plot of 4,4'-DDD Concentrations

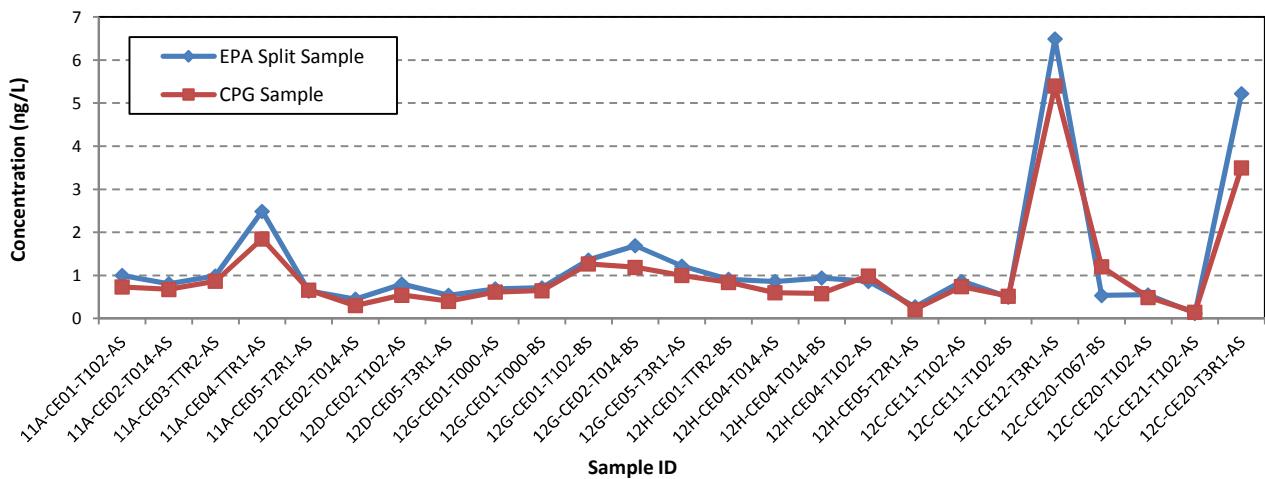


Figure 9b: Bivariate Plot of 4,4'-DDD Concentrations

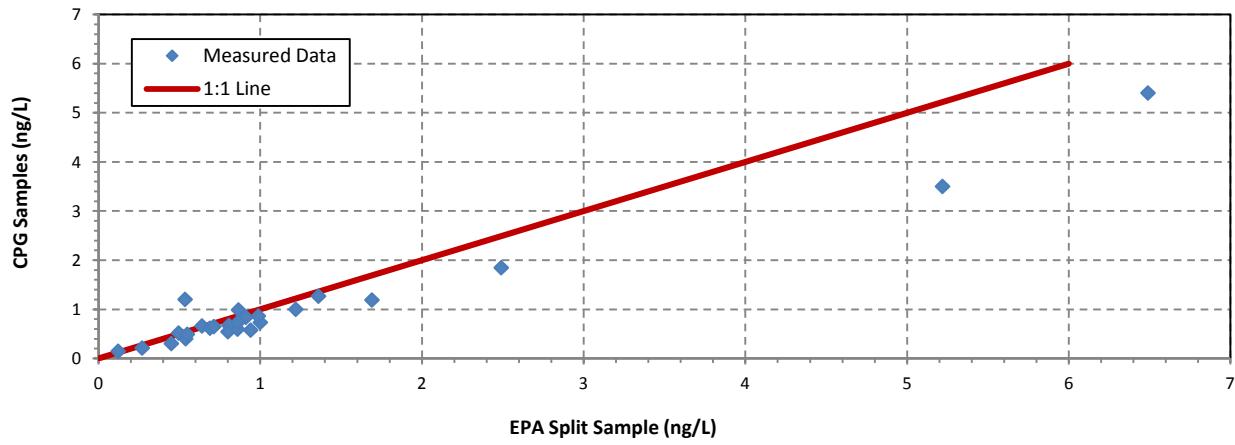


Figure 9c: Line Plot of 4,4'-DDD Percent Differences when EPA and CPG both had Detected Concentrations

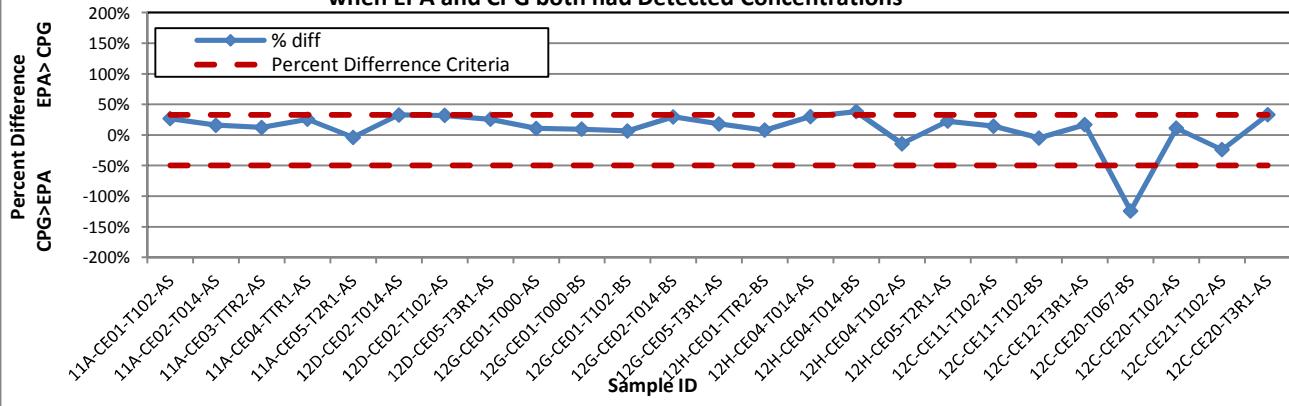


Figure 10a: Line Plot of 4,4'-DDE Concentrations

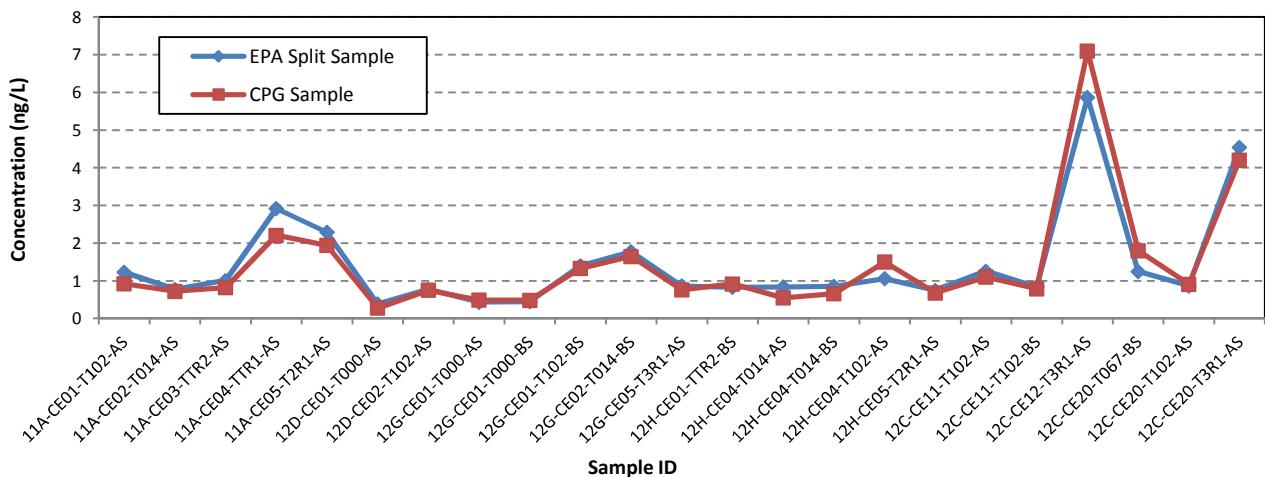


Figure 10b: Bivariate Plot of 4,4'-DDE Concentrations

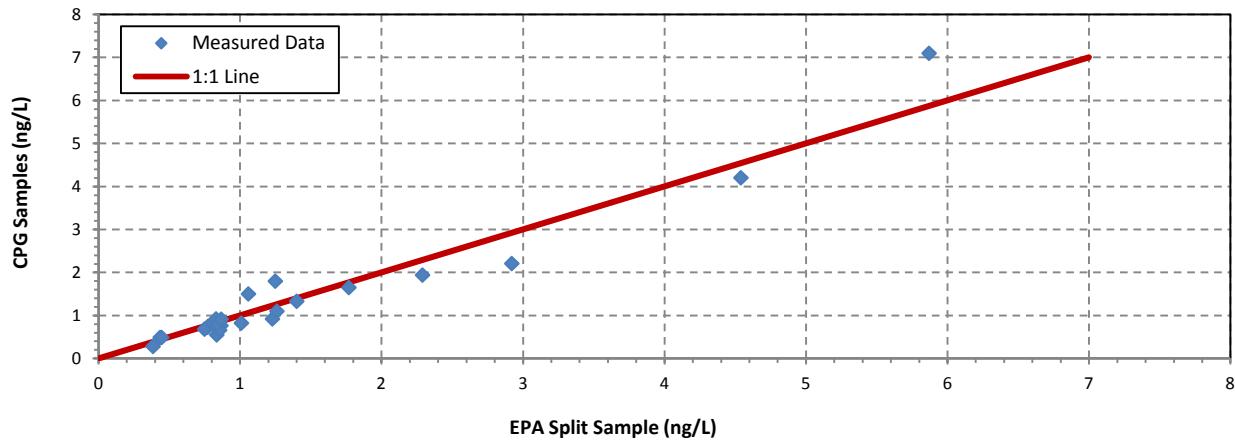
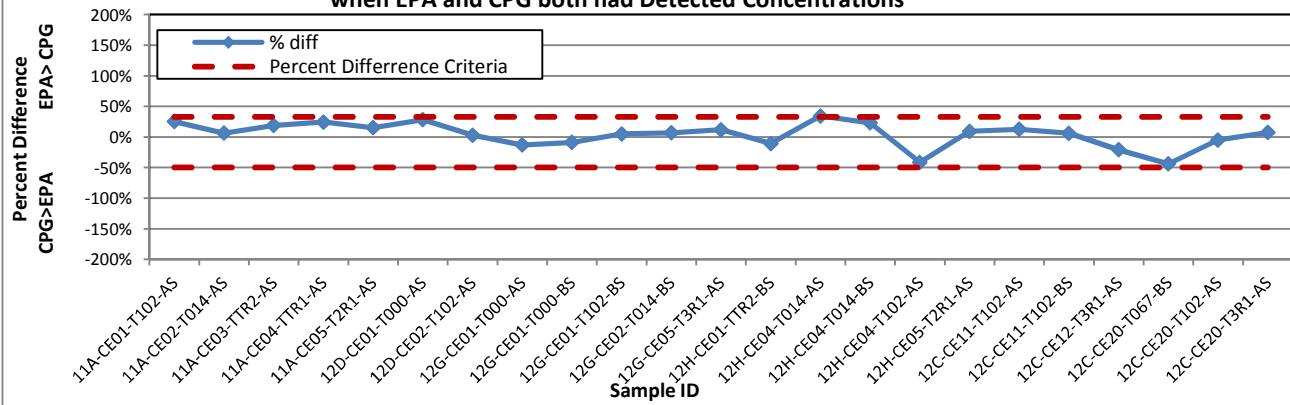


Figure 10c: Line Plot of 4,4'-DDE Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 4,4'-DDE Concentrations

Figure 10

ng/L - nanogram per liter

Figure 11a: Line Plot of 4,4'-DDT Concentrations

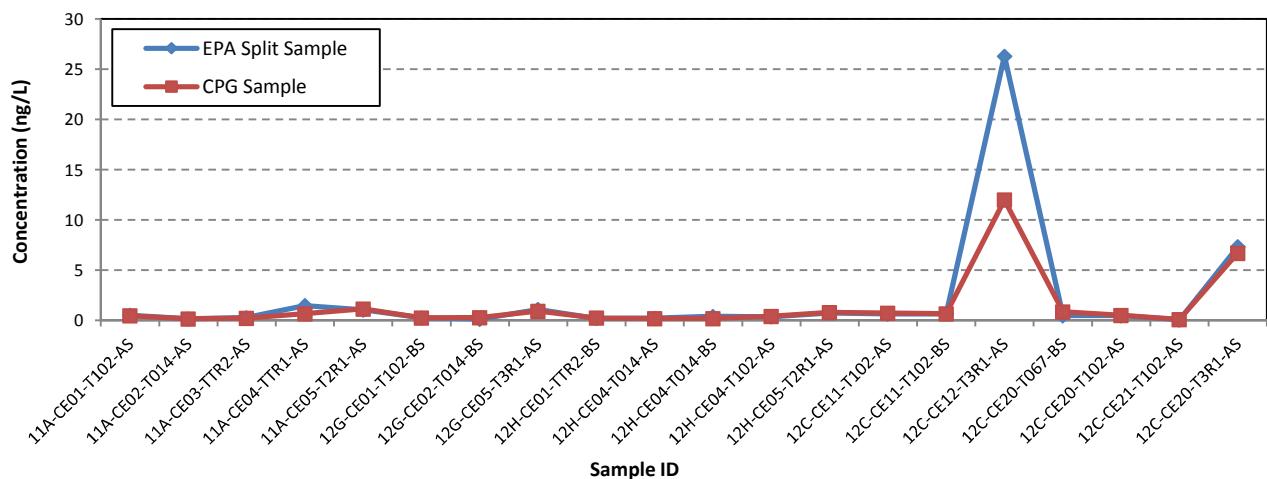


Figure 11b: Bivariate Plot of 4,4'-DDT Concentrations

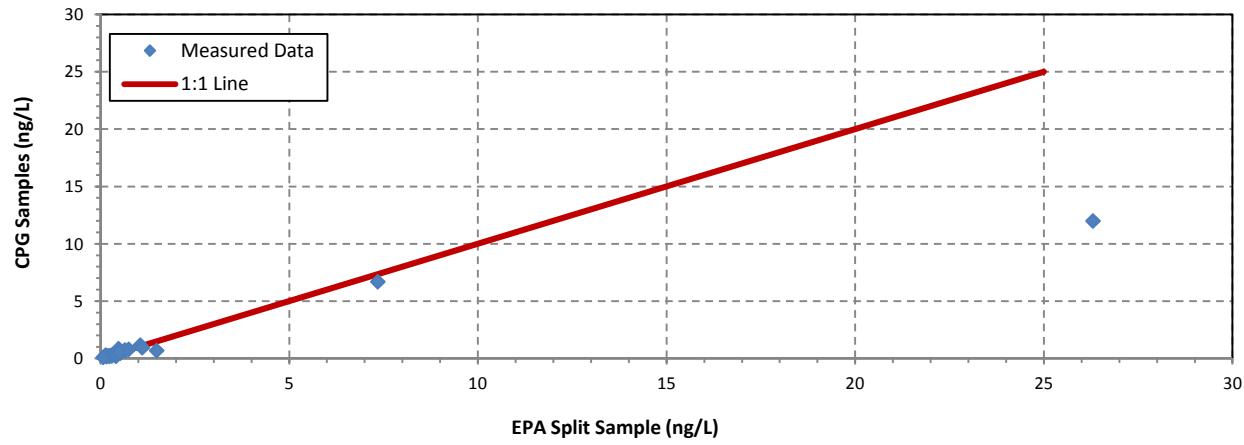


Figure 11c: Line Plot of 4,4'-DDT Percent Differences when EPA and CPG both had Detected Concentrations

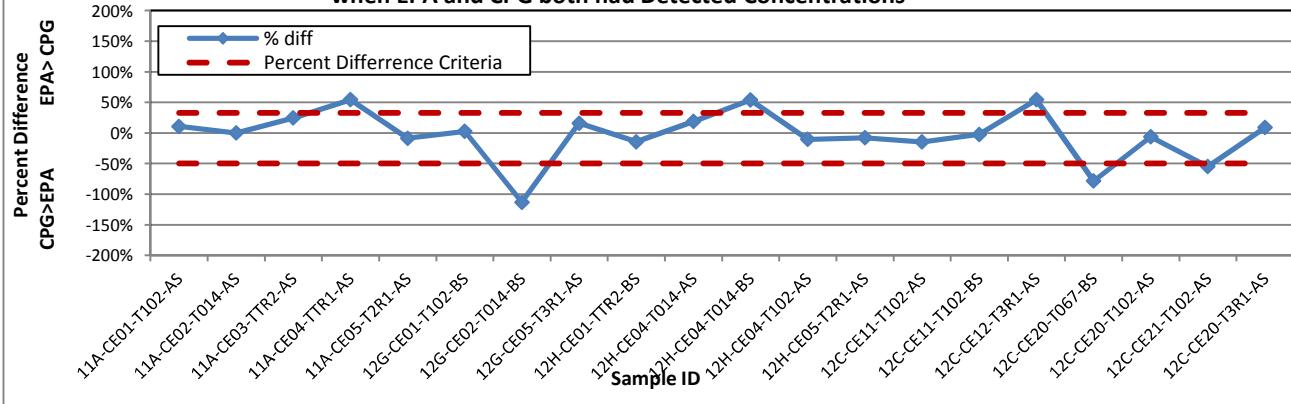


Figure 12a: Line Plot of Dieldrin Concentrations

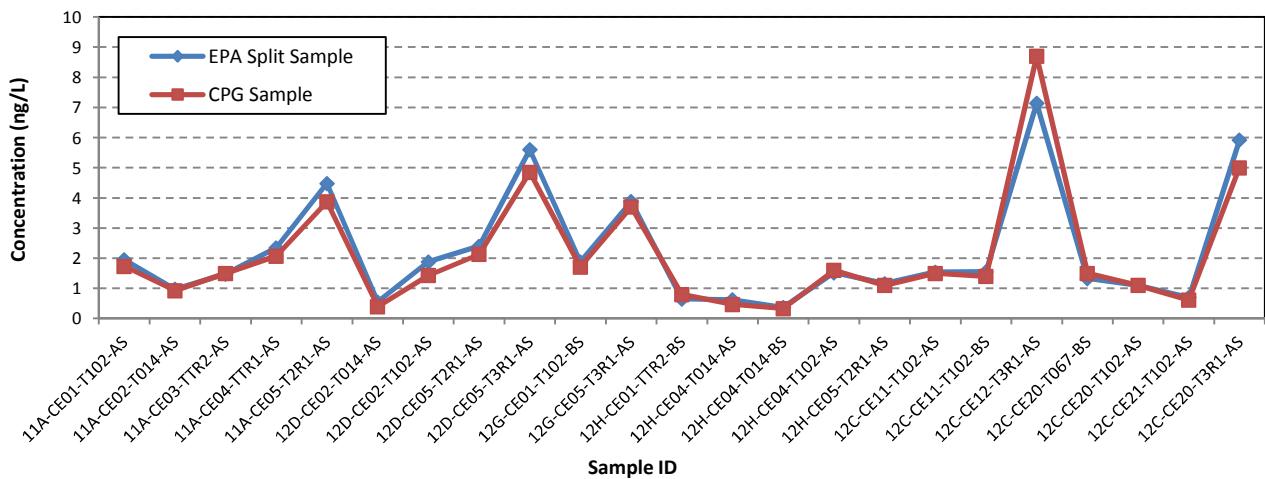


Figure 12b: Bivariate Plot of Dieldrin Concentrations

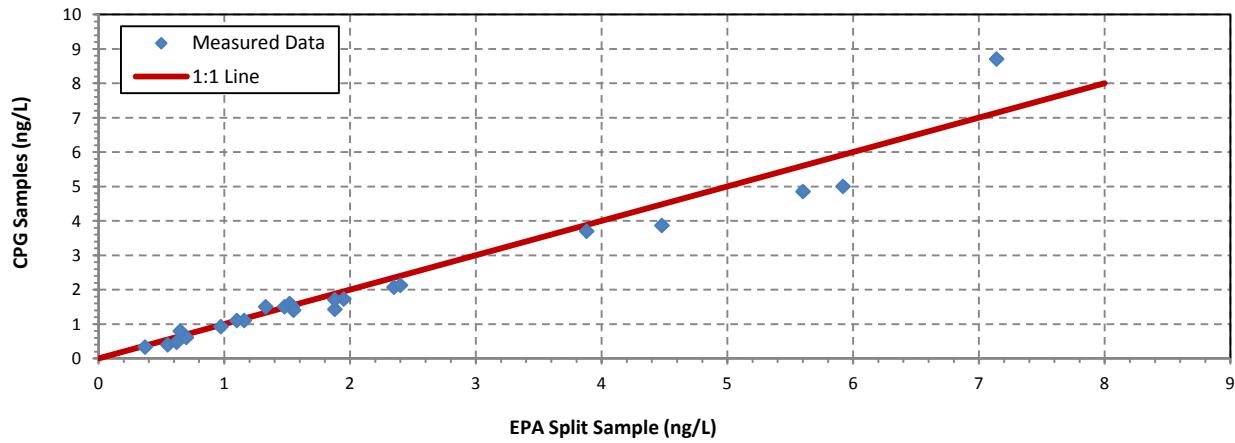


Figure 12c: Line Plot of Dieldrin Percent Differences when EPA and CPG both had Detected Concentrations

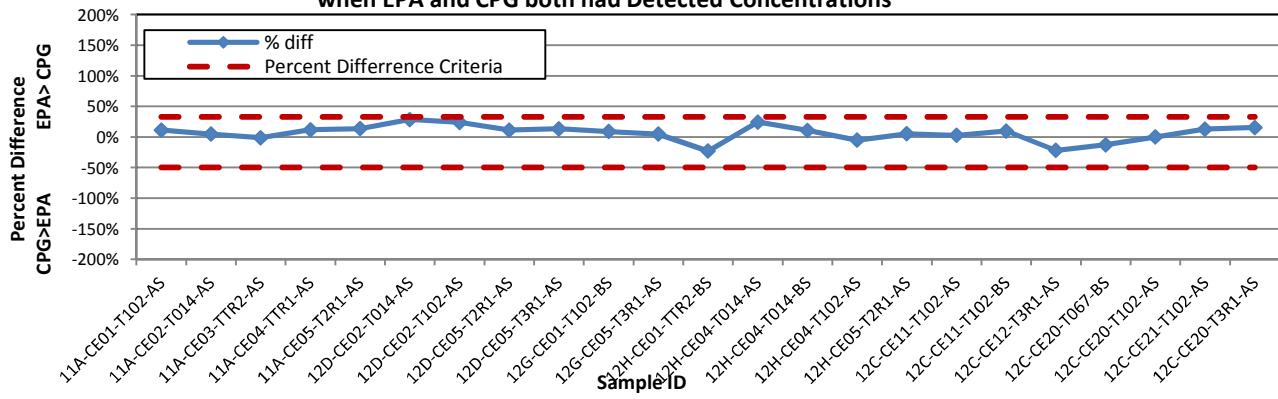


Figure 13a: Line Plot of Heptachlor Epoxide Concentrations

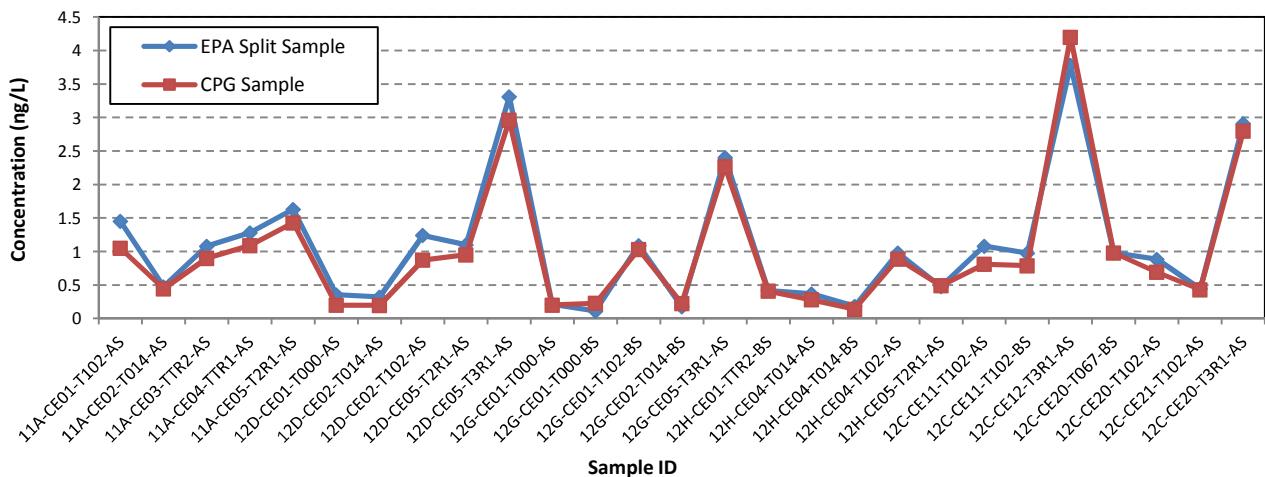


Figure 13b: Bivariate Plot of Heptachlor Epoxide Concentrations

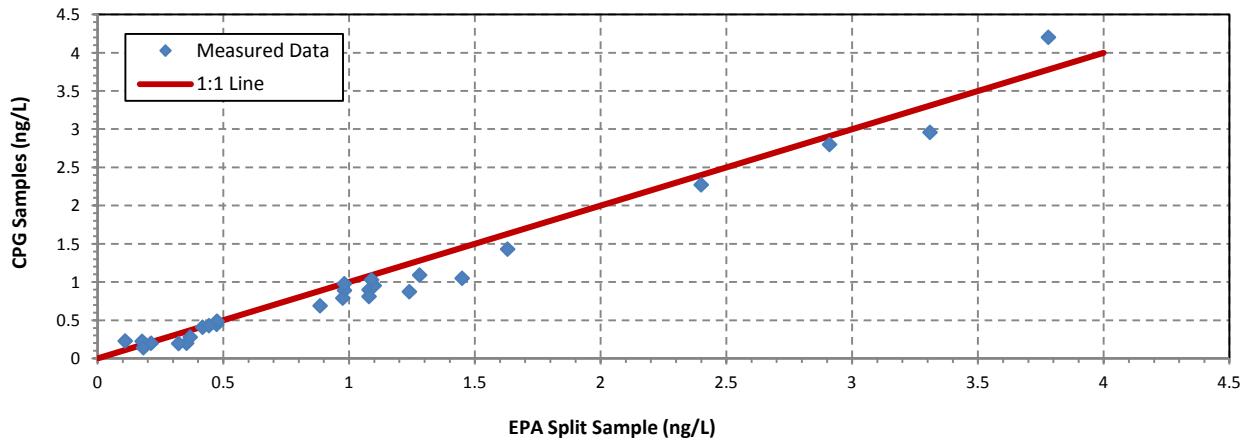


Figure 13c: Line Plot of Heptachlor Epoxide Percent Differences when EPA and CPG both had Detected Concentrations

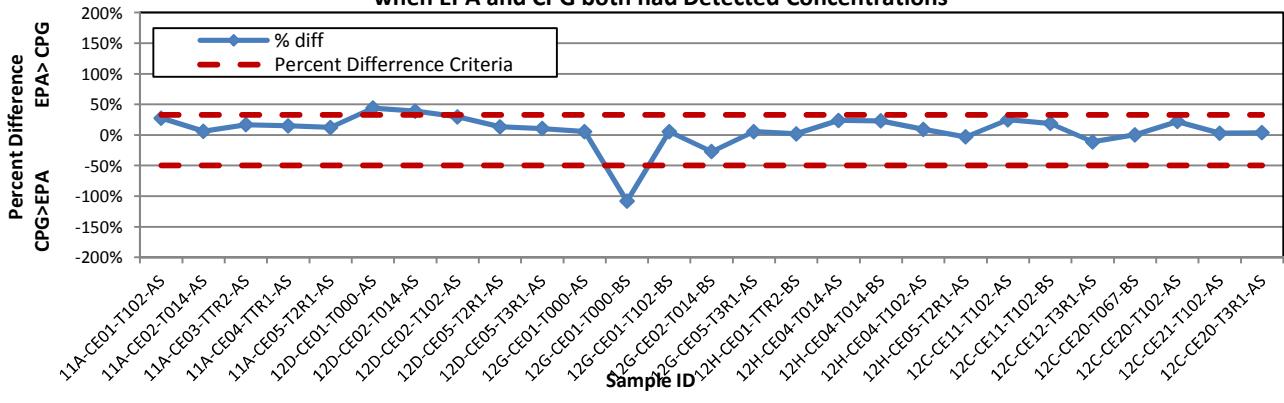


Figure 14a: Line Plot of cis-Nonachlor Concentrations

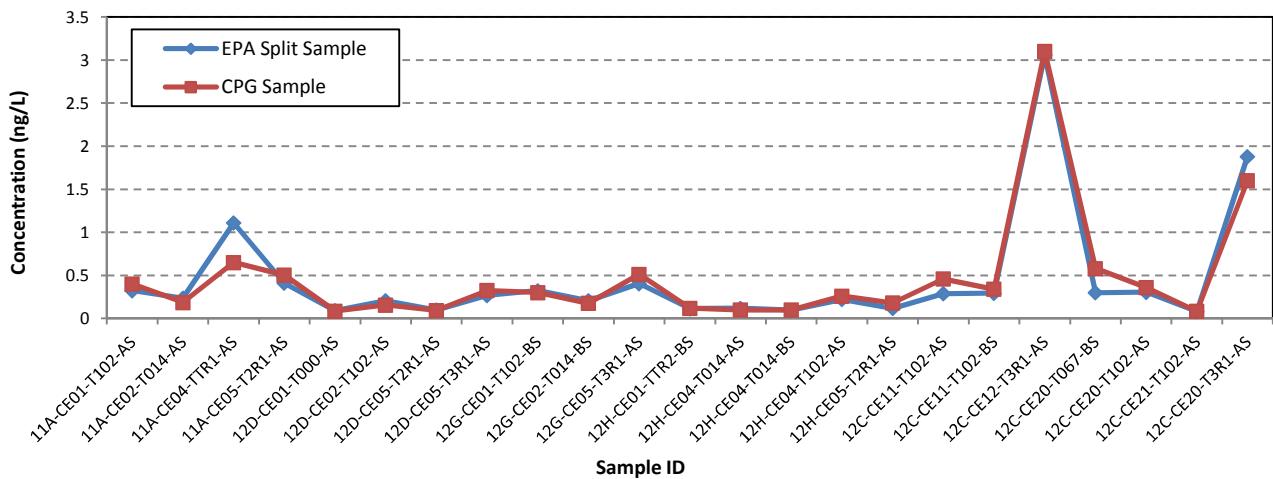


Figure 14b: Bivariate Plot of cis-Nonachlor Concentrations

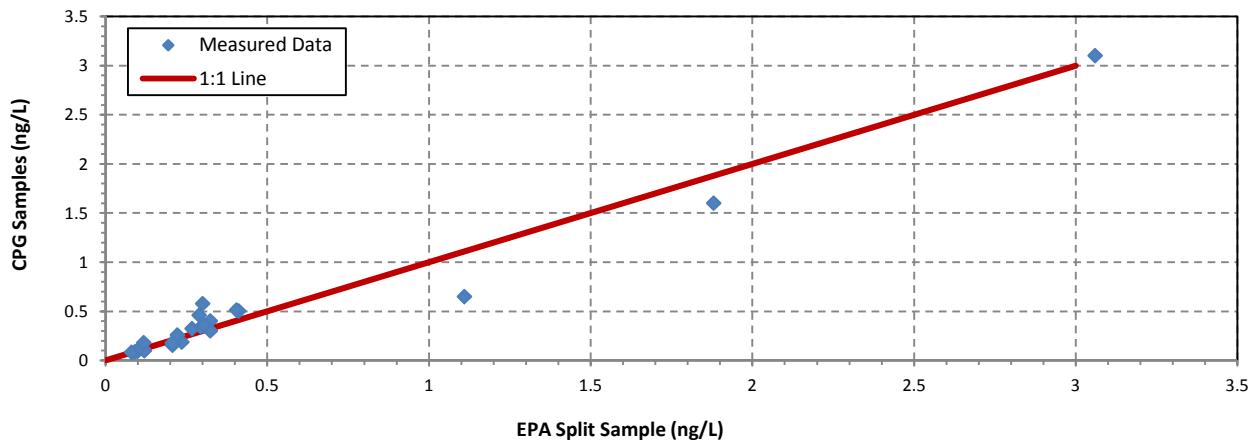


Figure 14c: Line Plot of cis-Nonachlor Percent Differences when EPA and CPG both had Detected Concentrations

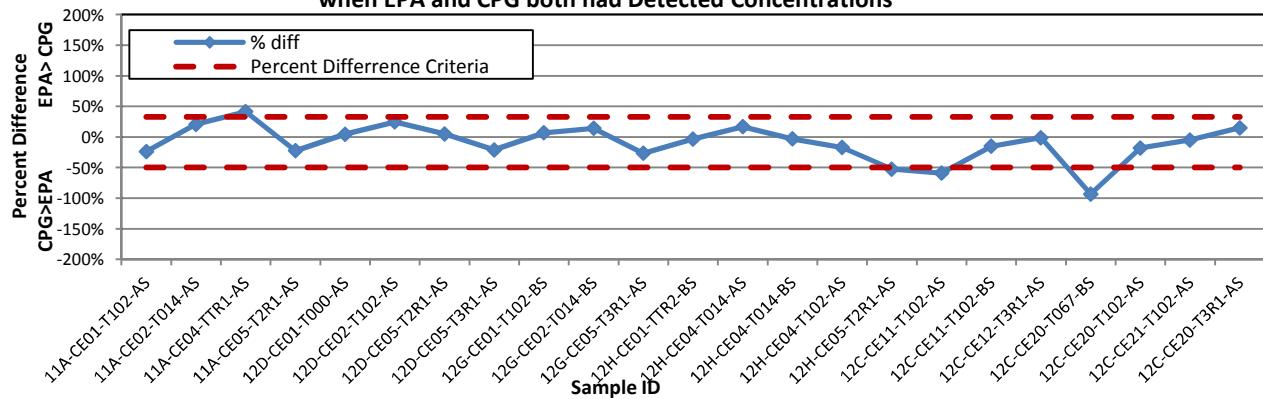


Figure 15a: Line Plot of trans-Nonachlor Concentrations

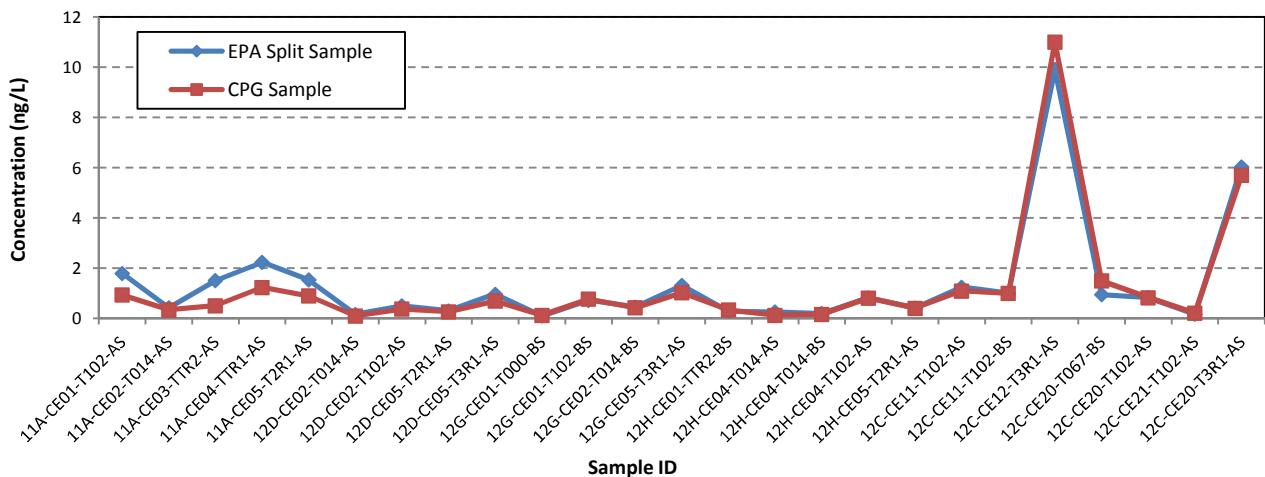


Figure 15b: Bivariate Plot of trans-Nonachlor Concentrations

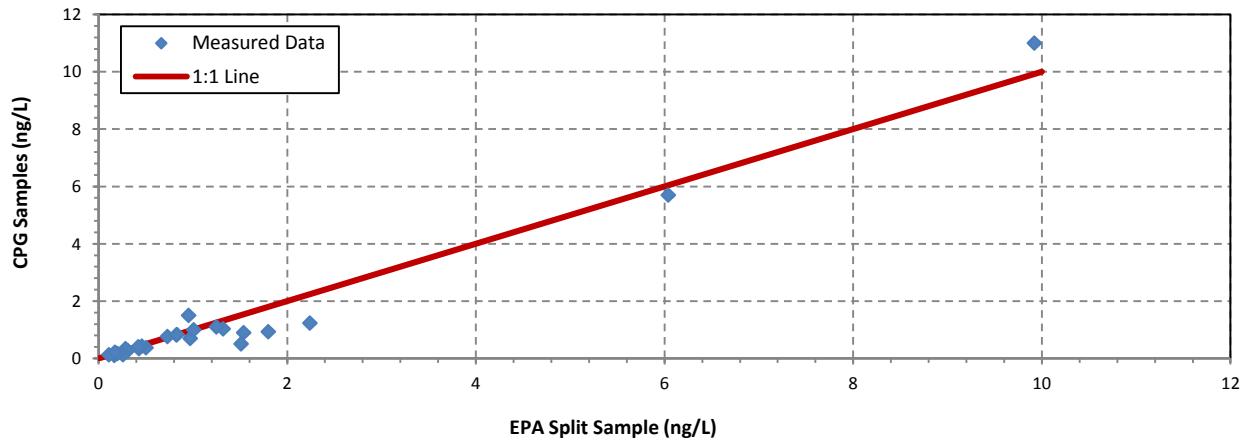


Figure 15c: Line Plot of trans-Nonachlor Percent Differences when EPA and CPG both had Detected Concentrations

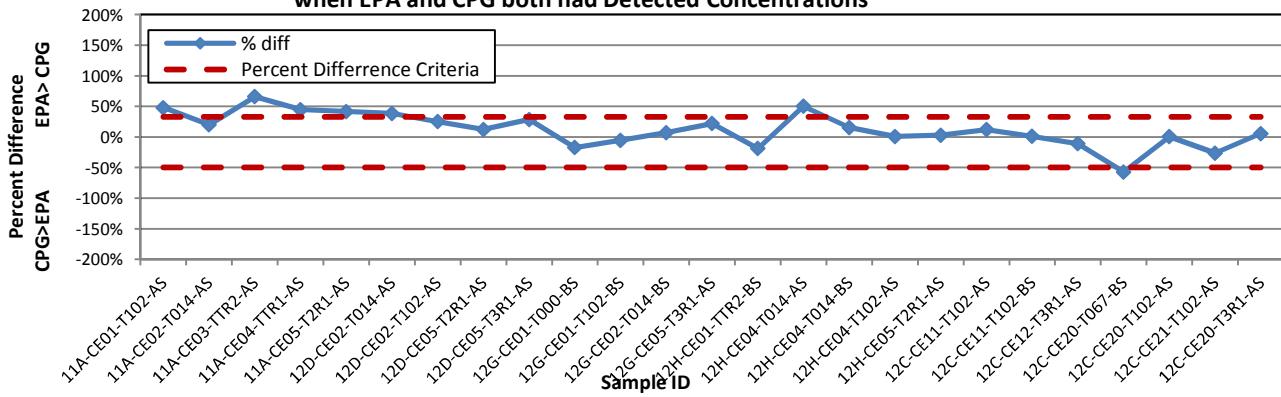


Figure 16a: Line Plot of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Concentrations

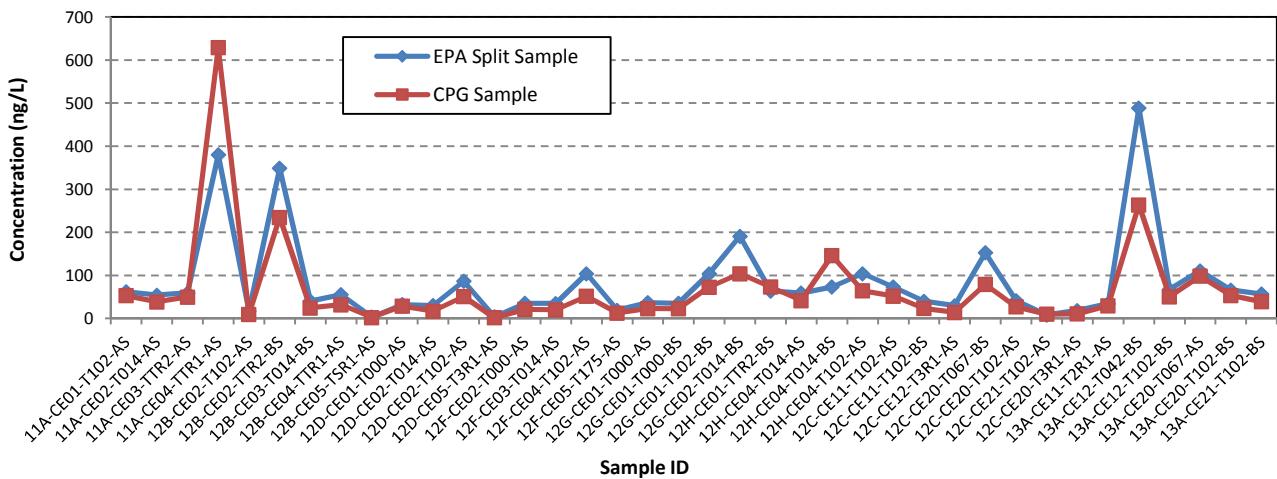


Figure 16b: Bivariate Plot of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Concentrations

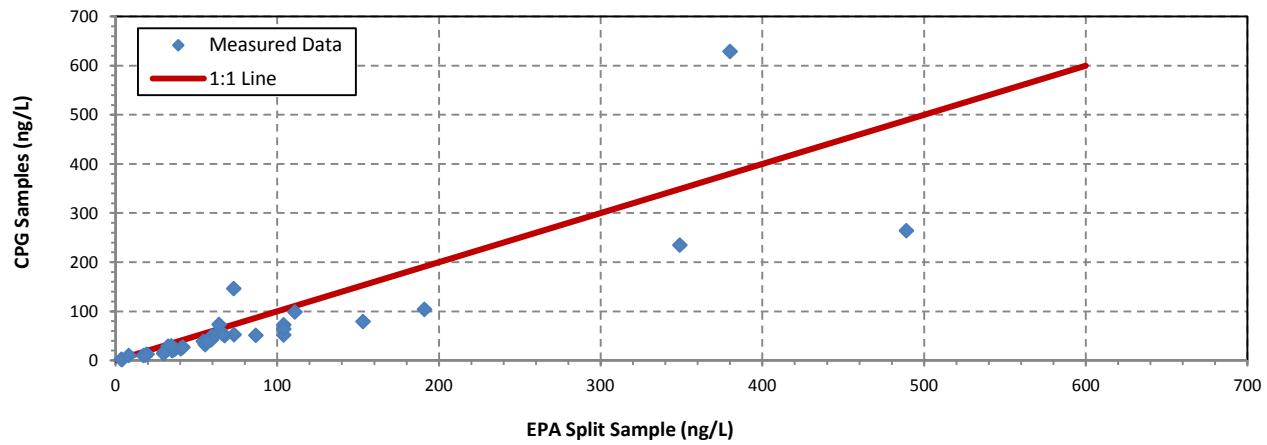
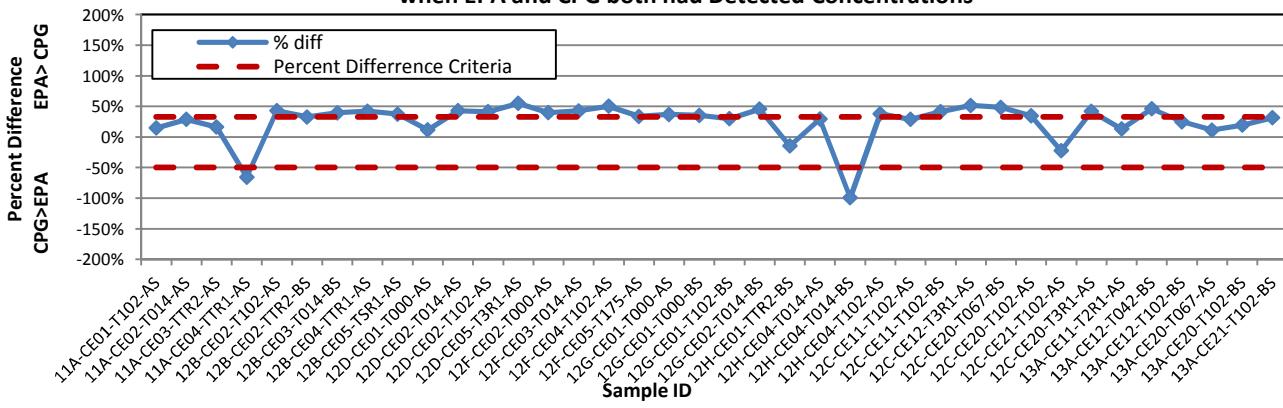


Figure 16c: Line Plot of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Concentrations

Figure 16

Figure 17a: Line Plot of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Concentrations

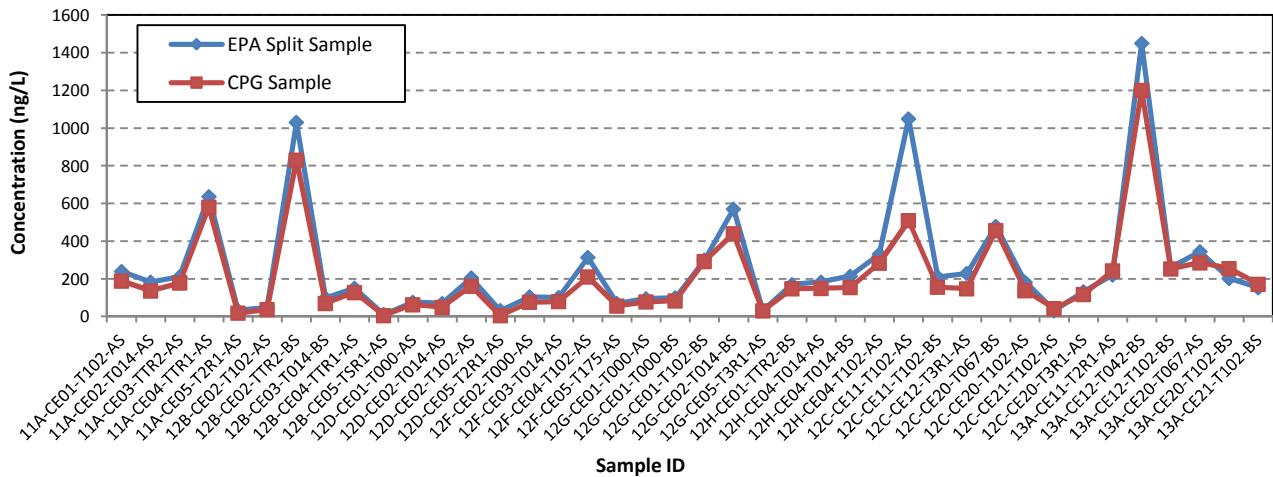


Figure 17b: Bivariate Plot of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Concentrations

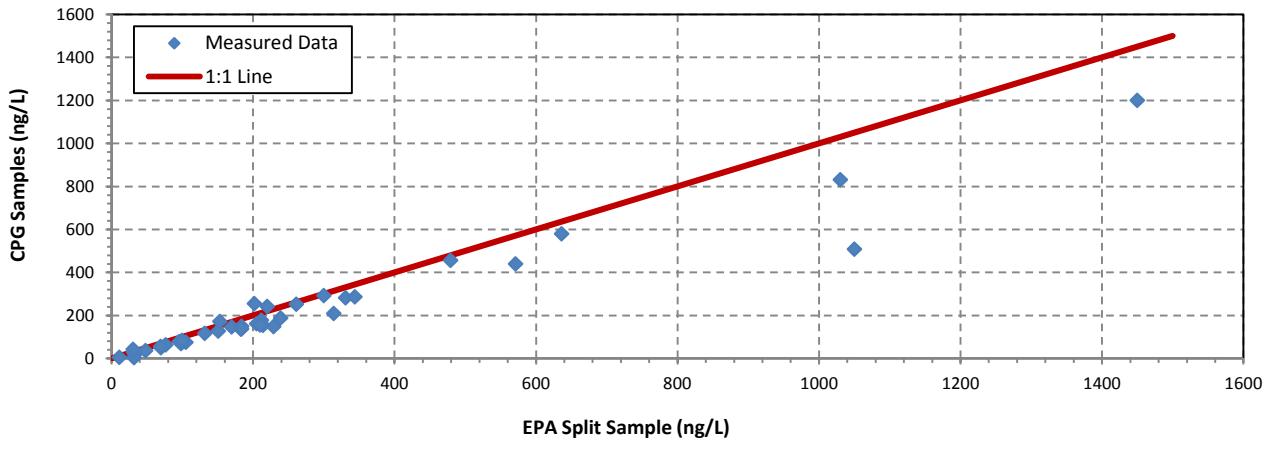
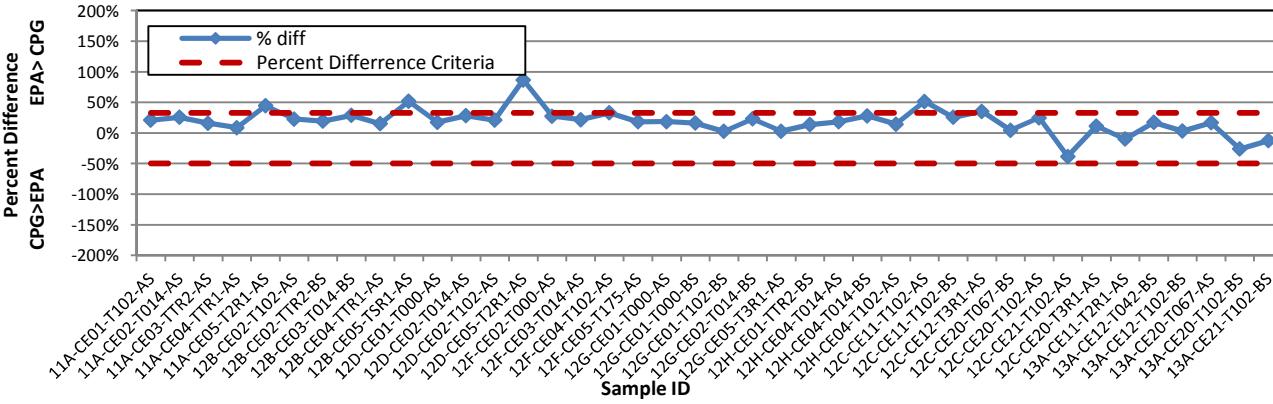


Figure 17c: Line Plot of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Concentrations

Figure 17

ng/L - nanogram per liter

Figure 18a: Line Plot of 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) Concentrations

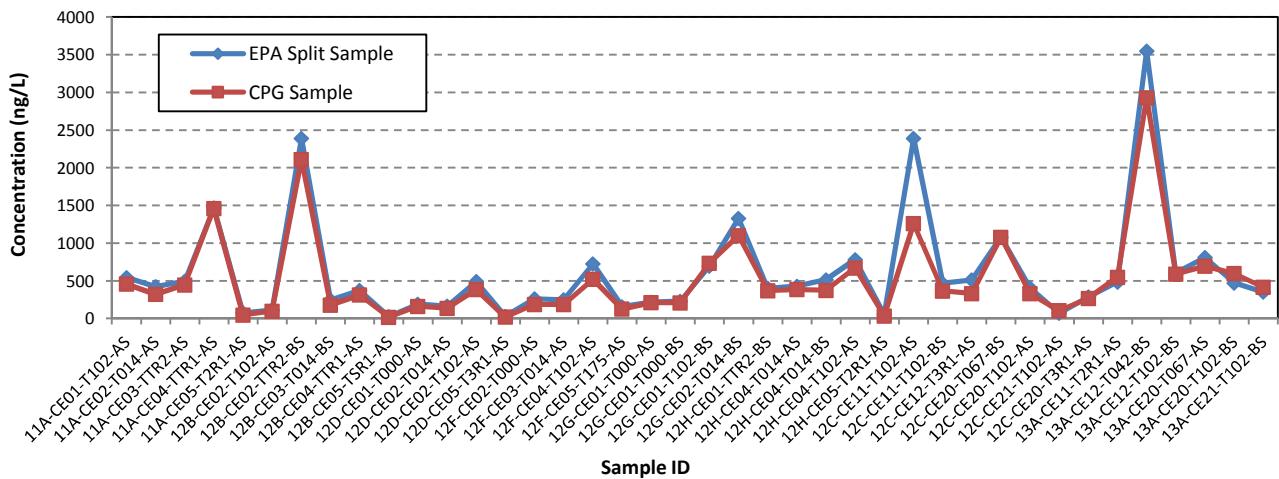


Figure 19a: Line Plot of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Concentrations

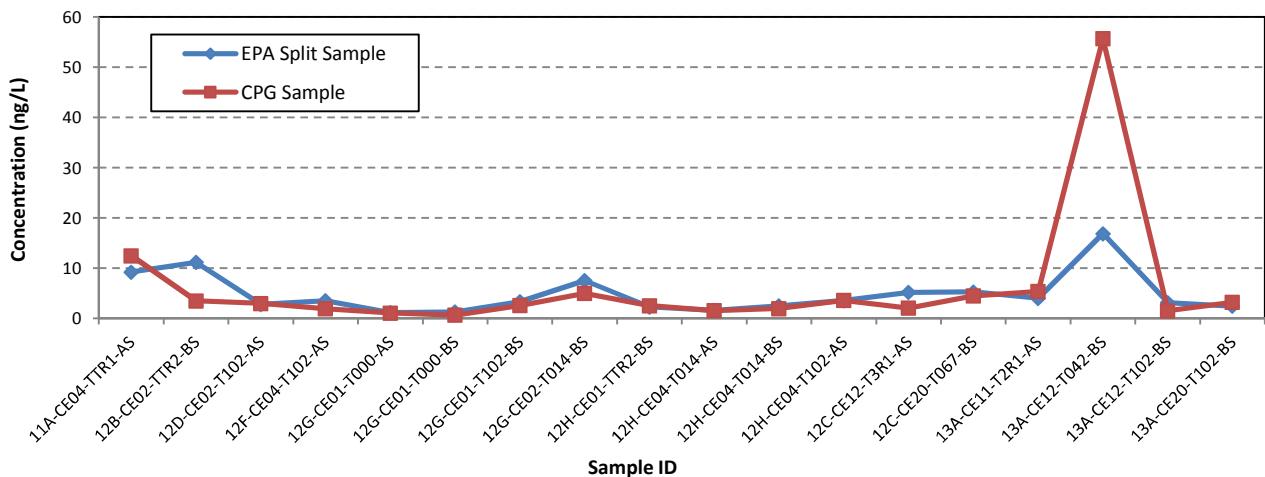


Figure 19b: Bivariate Plot of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Concentrations

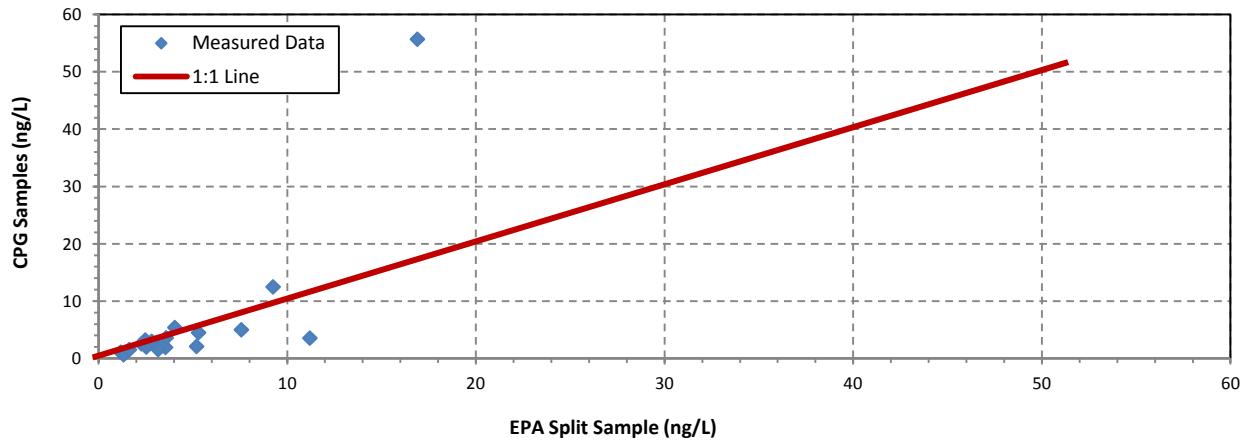
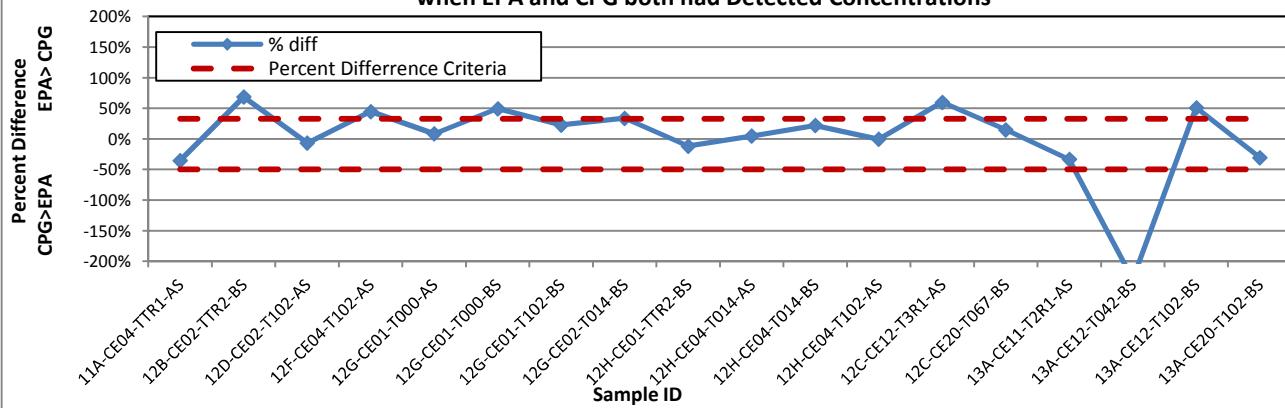


Figure 19c: Line Plot of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Concentrations

Figure 19

ng/L - nanogram per liter

Figure 20a: Line Plot of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Concentrations

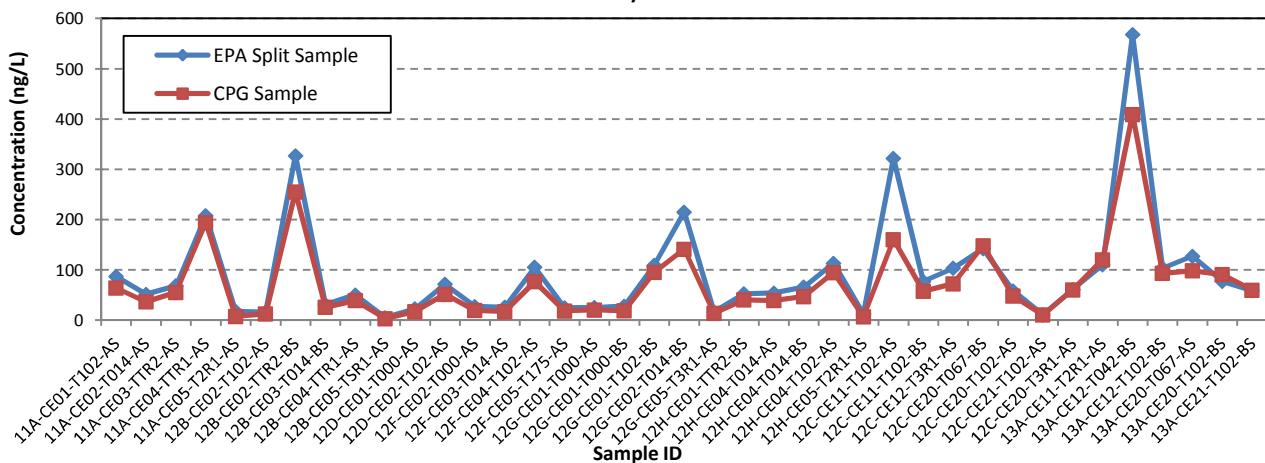


Figure 20b: Bivariate Plot of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Concentrations

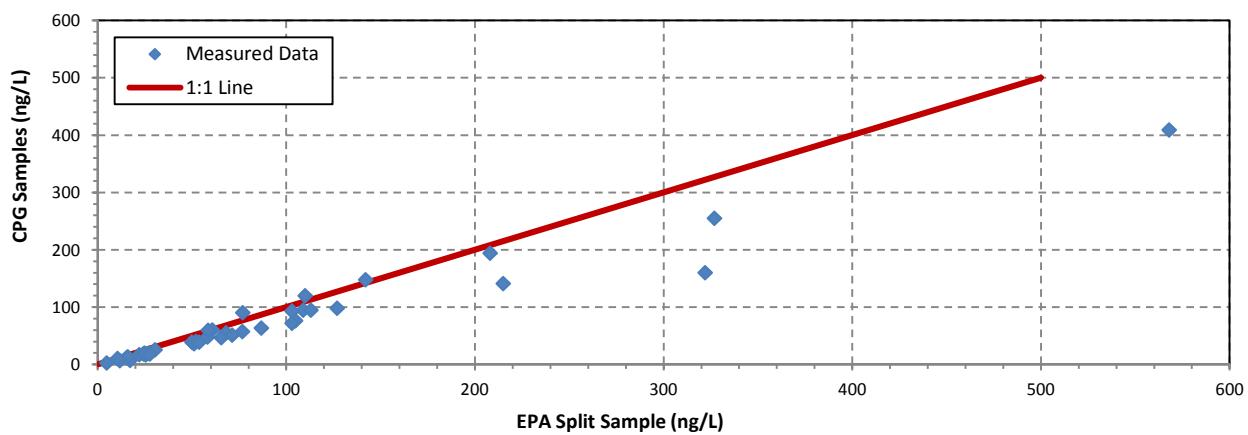
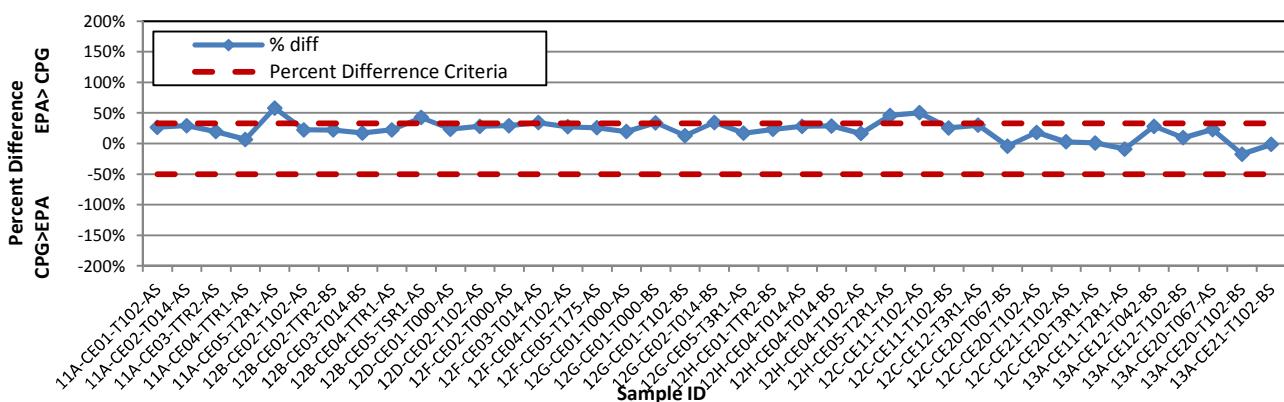


Figure 20c: Line Plot of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Concentrations

Figure 20

ng/L - nanogram per liter

Figure 21a: Line Plot of Total Hexachlorobiphenyls Concentrations

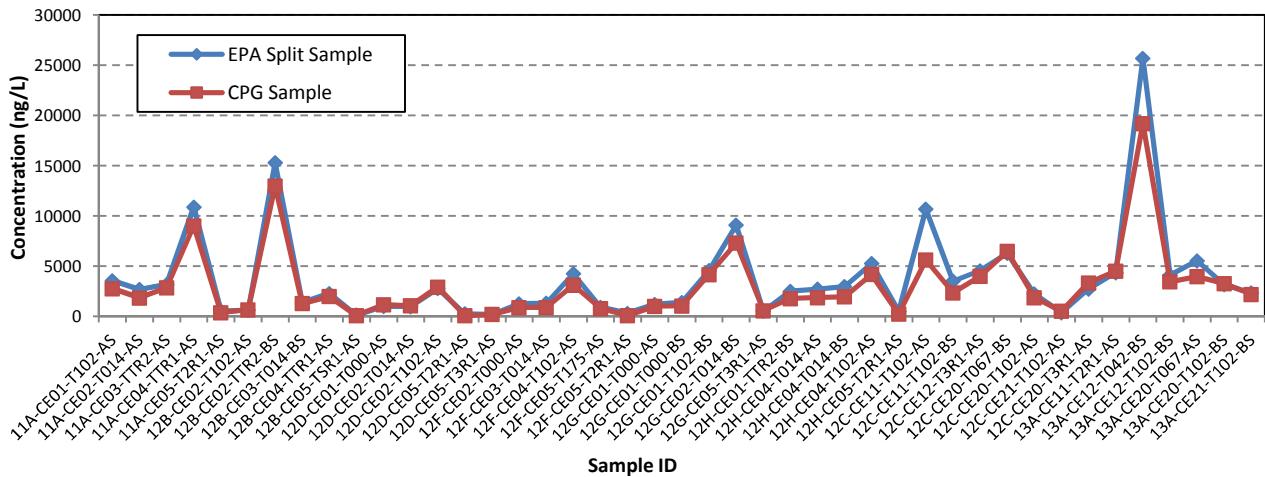


Figure 21b: Bivariate Plot of Total Hexachlorobiphenyls Concentrations

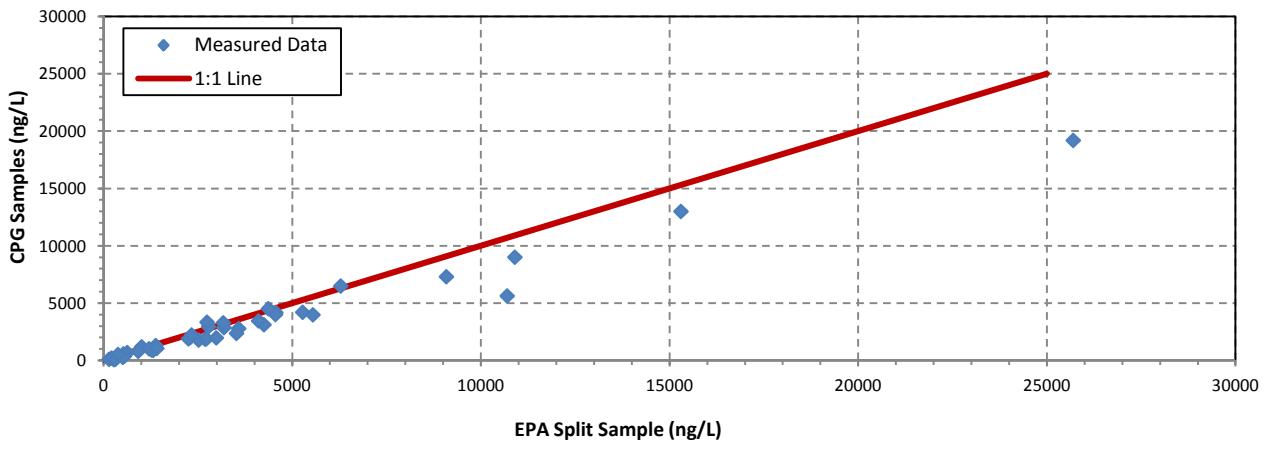


Figure 21c: Line Plot of Total Hexachlorobiphenyls Percent Differences when EPA and CPG both had Detected Concentrations

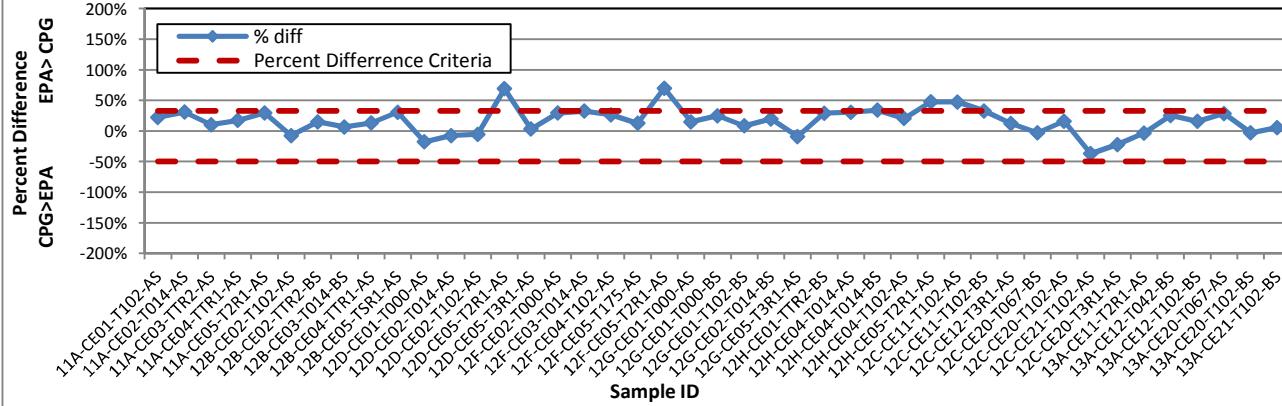


Figure 22a: Line Plot of Total Octachlorobiphenyls Concentrations

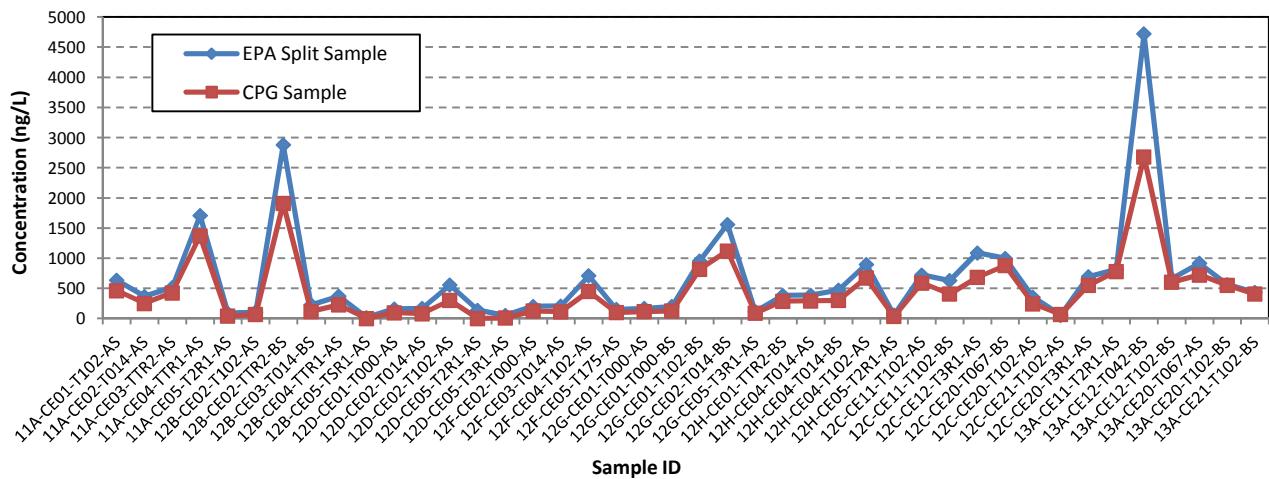


Figure 22b: Bivariate Plot of Total Octachlorobiphenyls Concentrations

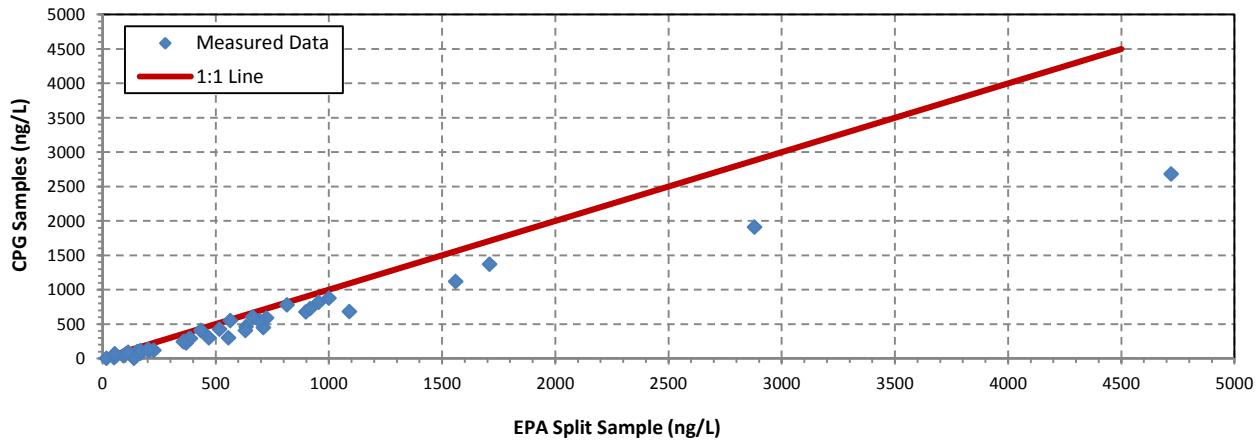


Figure 22c: Line Plot of Total Octachlorobiphenyls Percent Differences when EPA and CPG both had Detected Concentrations

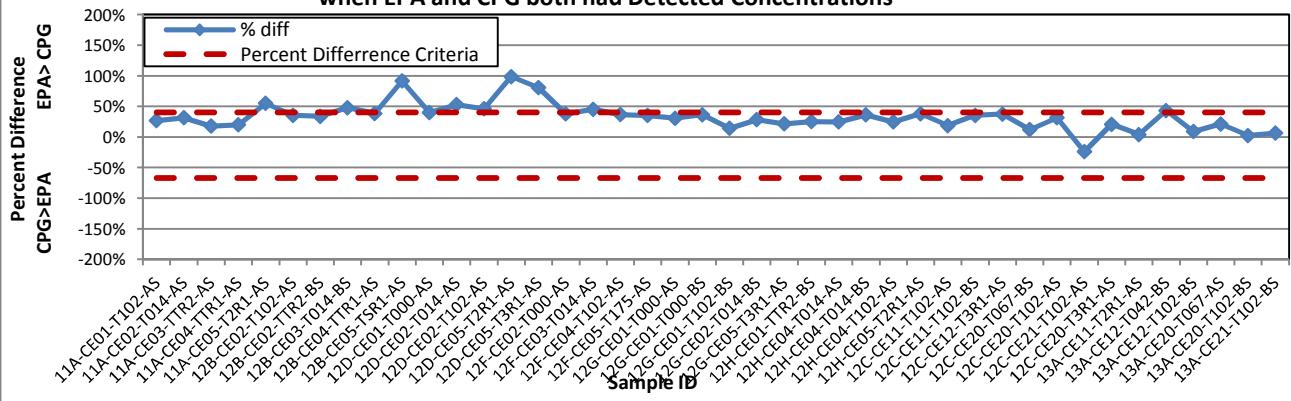


Figure 23a: Line Plot of Total Pentachlorobiphenyls Concentrations

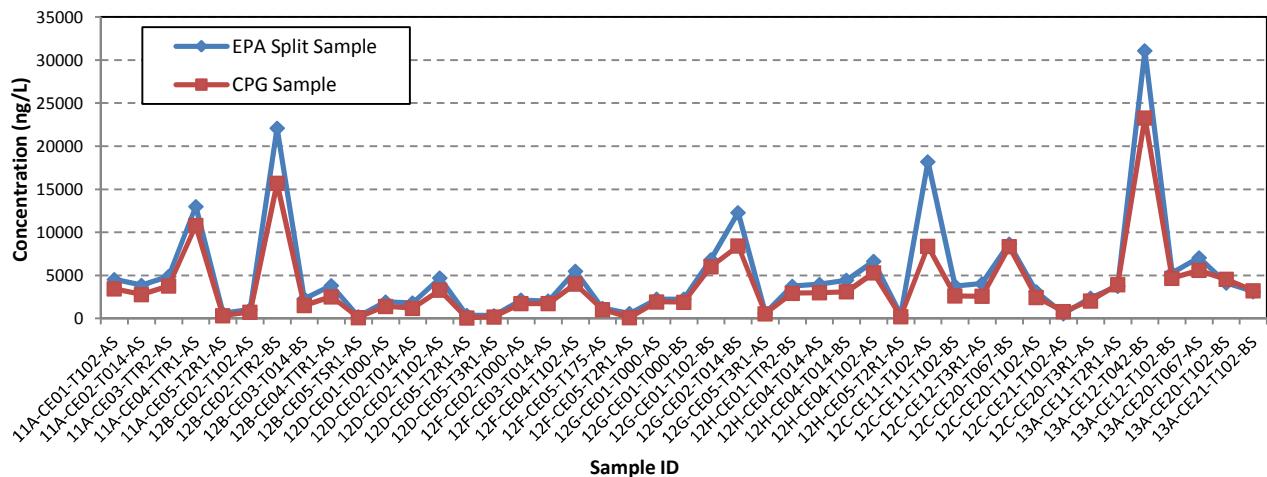


Figure 23b: Bivariate Plot of Total Pentachlorobiphenyls Concentrations

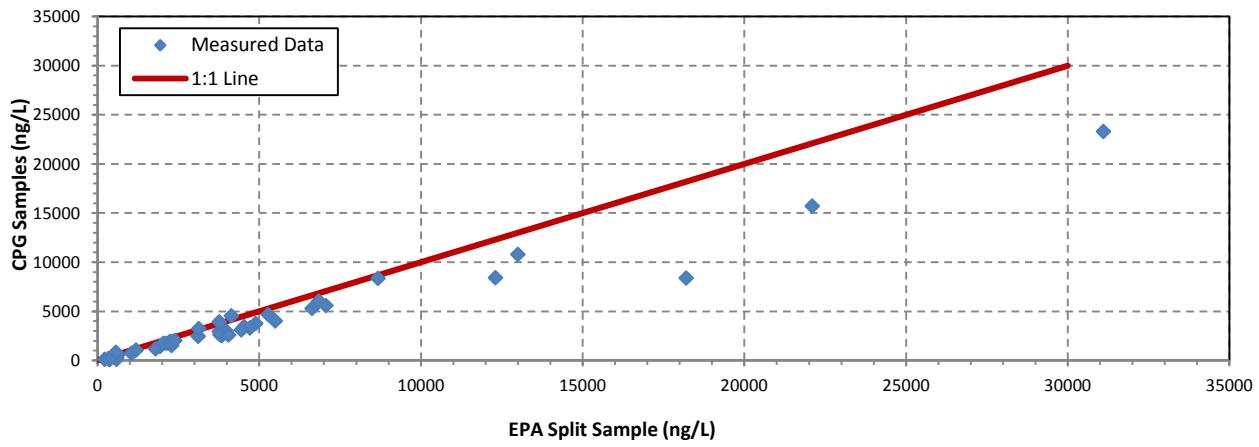


Figure 23c: Line Plot of Total Pentachlorobiphenyls Percent Differences when EPA and CPG both had Detected Concentrations

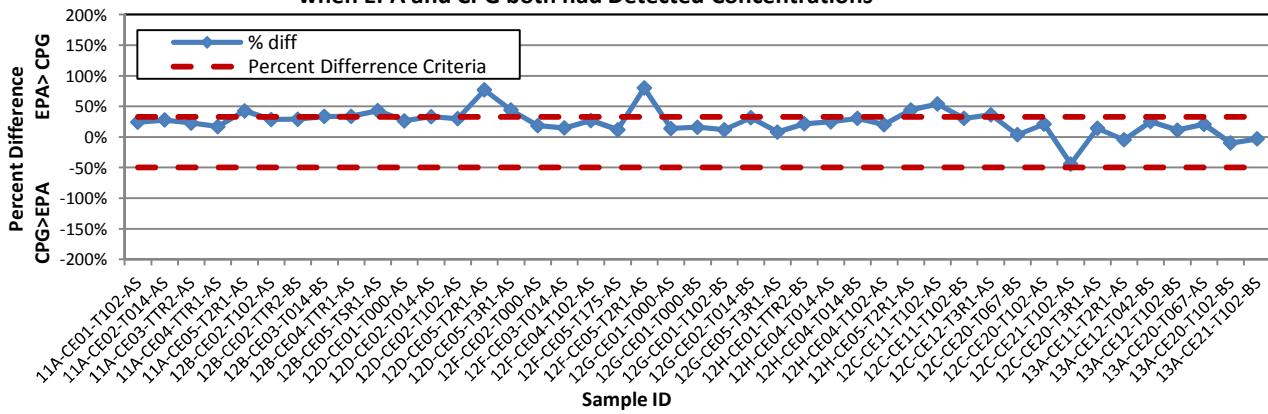


Figure 24a: Line Plot of Total Tetrachlorobiphenyls Concentrations

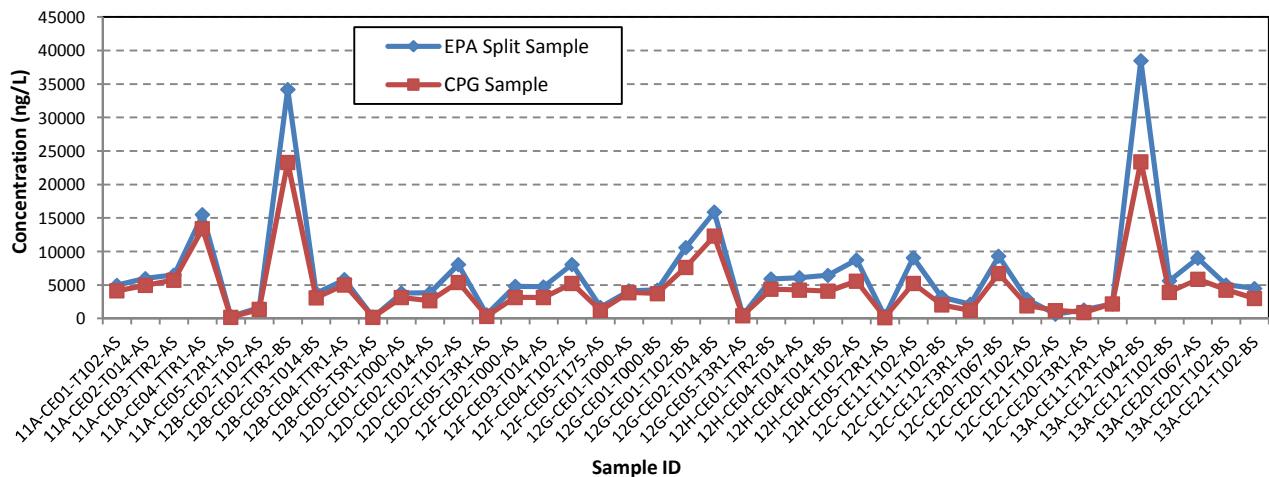


Figure 24b: Bivariate Plot of Total Tetrachlorobiphenyls Concentrations

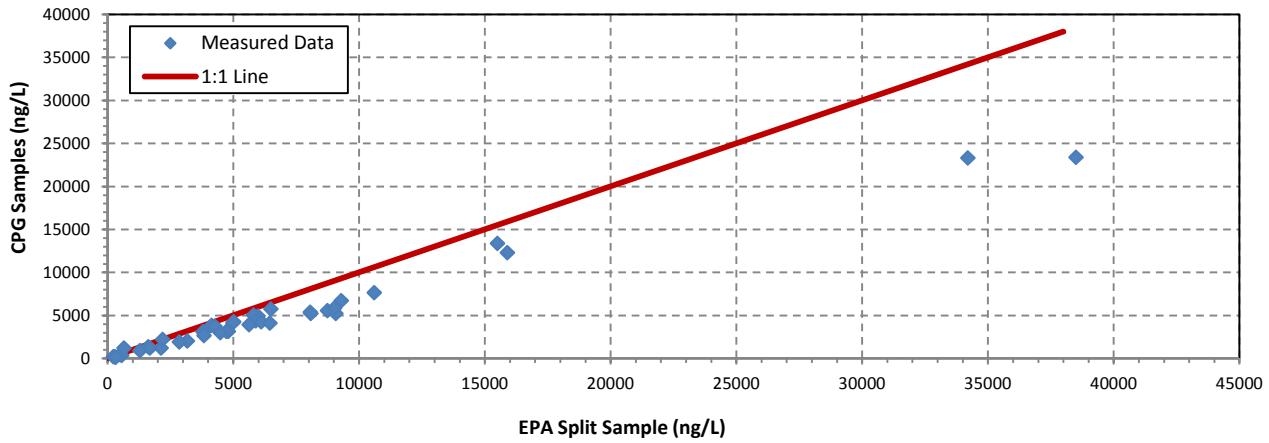


Figure 24c: Line Plot of Total Tetrachlorobiphenyls Percent Differences when EPA and CPG both had Detected Concentrations

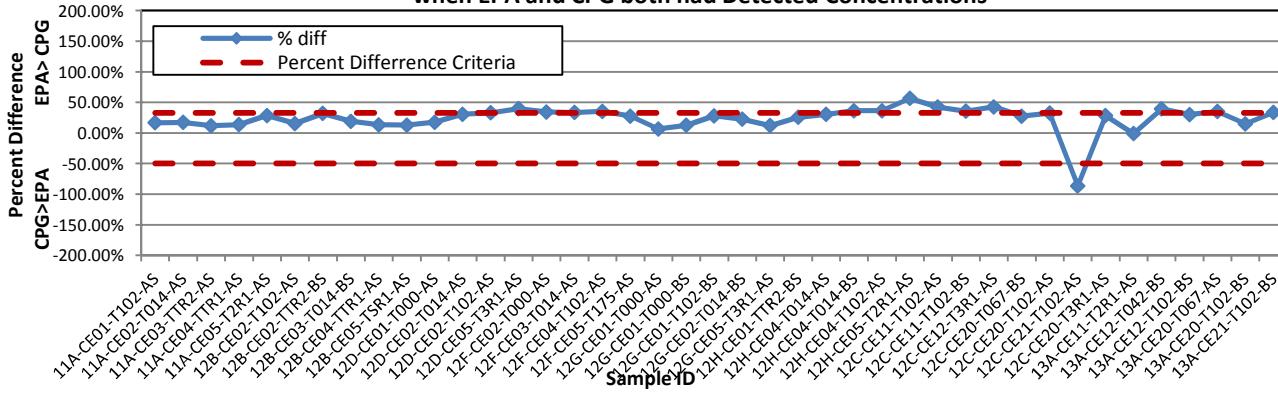


Figure 25a: Line Plot of Total Trichlorobiphenyls Concentrations

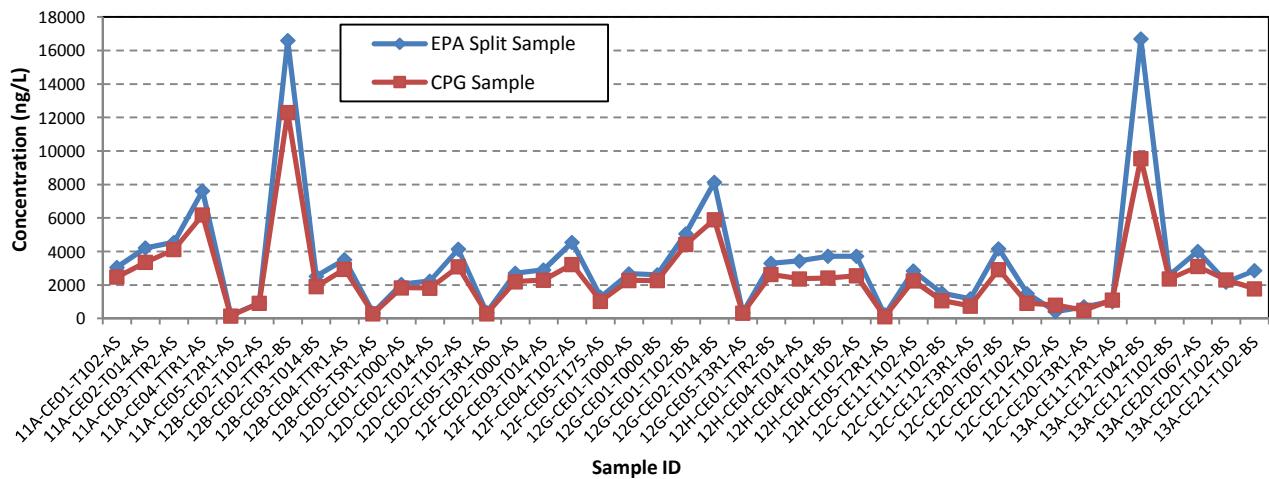


Figure 25b: Bivariate Plot of Total Trichlorobiphenyls Concentrations

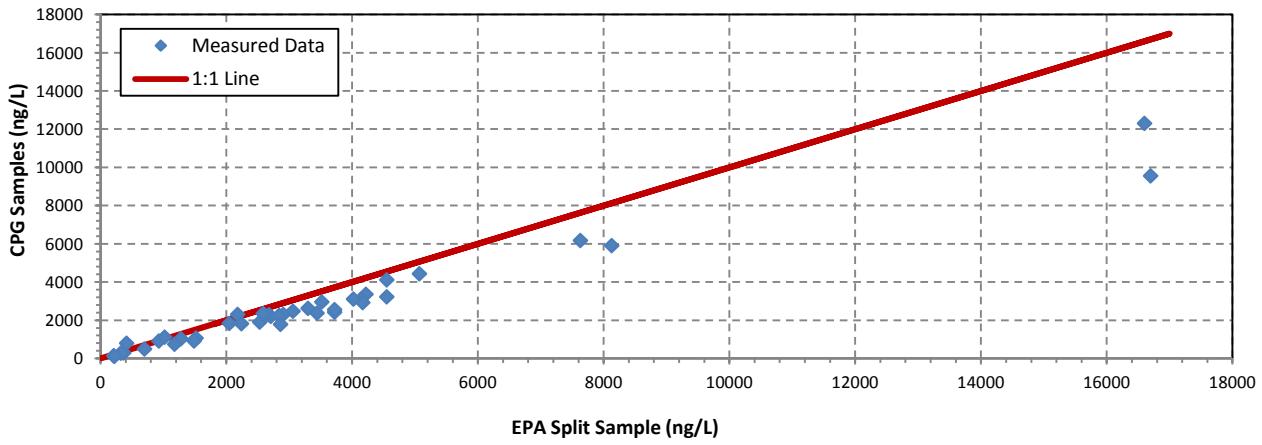
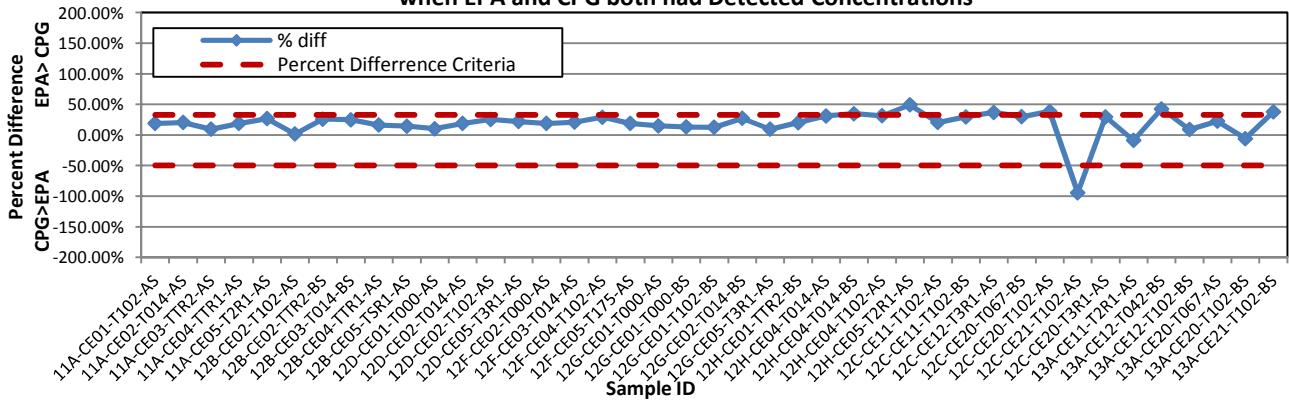


Figure 25c: Line Plot of Total Trichlorobiphenyls Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total Trichlorobiphenyls Concentrations

Figure 25

Figure 26a: Line Plot of Total PCBs Concentrations

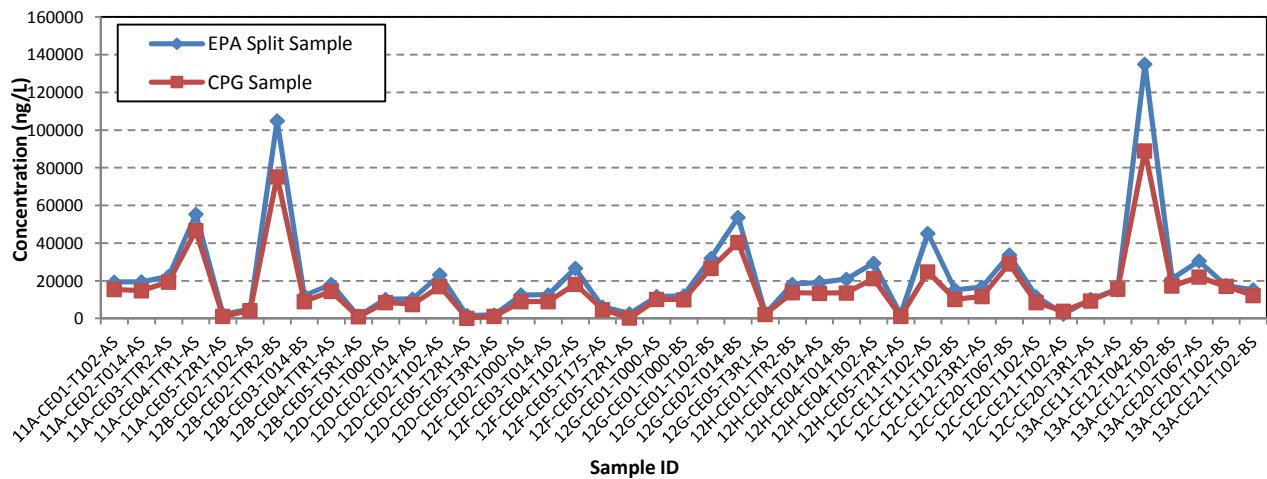


Figure 26b: Bivariate Plot of Total PCBs Concentrations

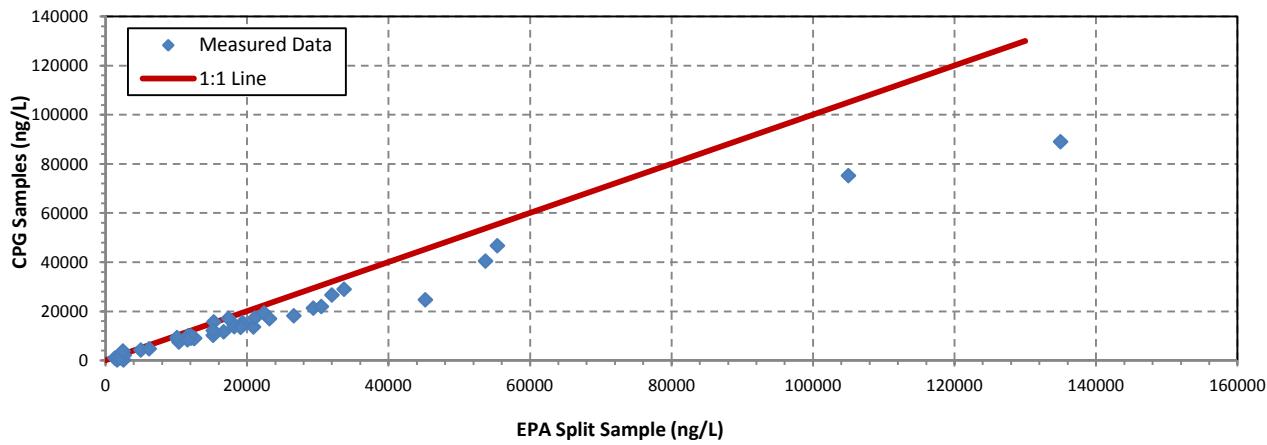
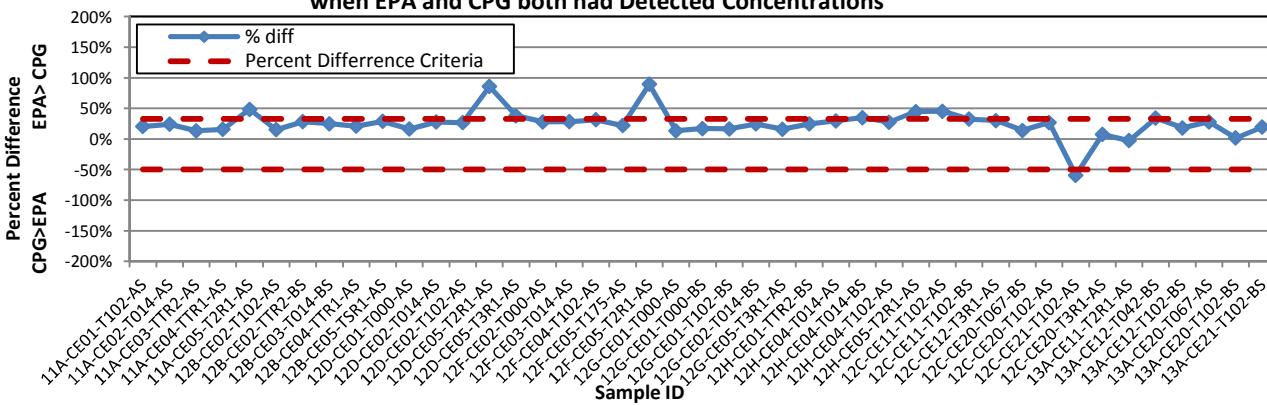


Figure 26c: Line Plot of Total PCBs Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total PCBs Concentrations

Figure 26

ng/L - nanogram per liter

Figure 27a: Line Plot of Benzo[a]anthracene Concentrations

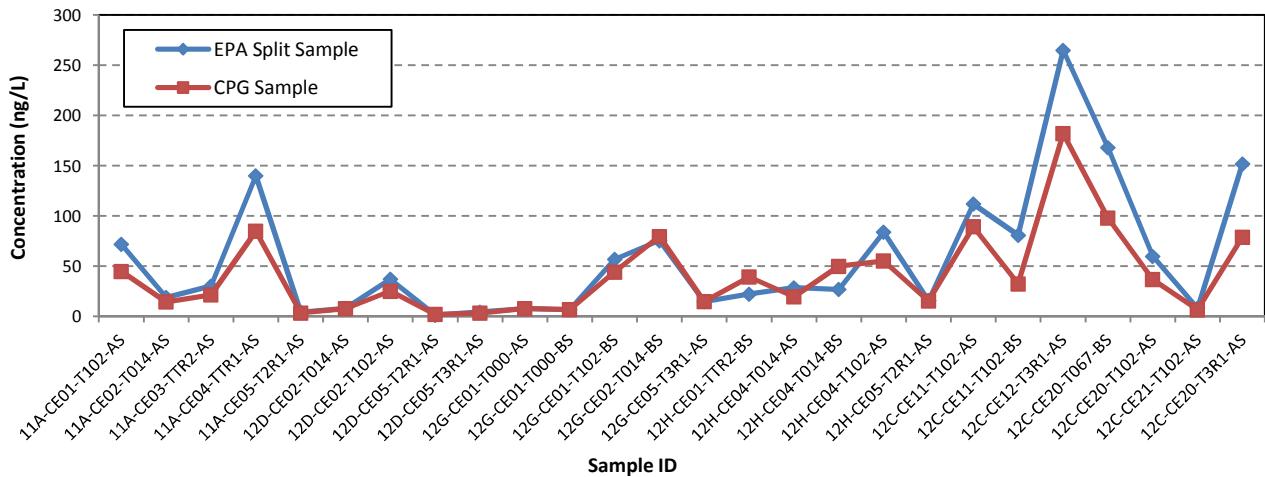


Figure 27b: Bivariate Plot of Benz[a]anthracene Concentrations

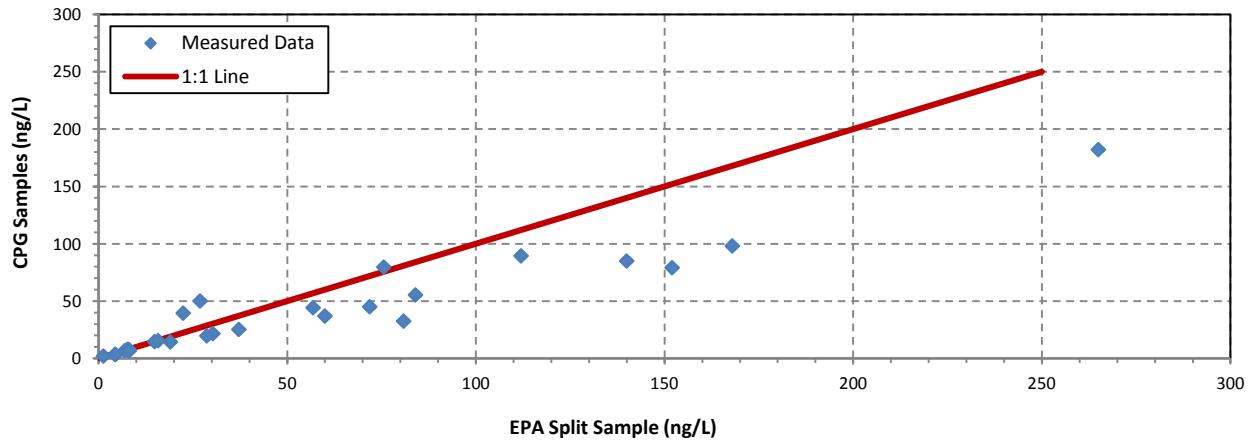


Figure 27c: Line Plot of Benz[a]anthracene Percent Differences when EPA and CPG both had Detected Concentrations

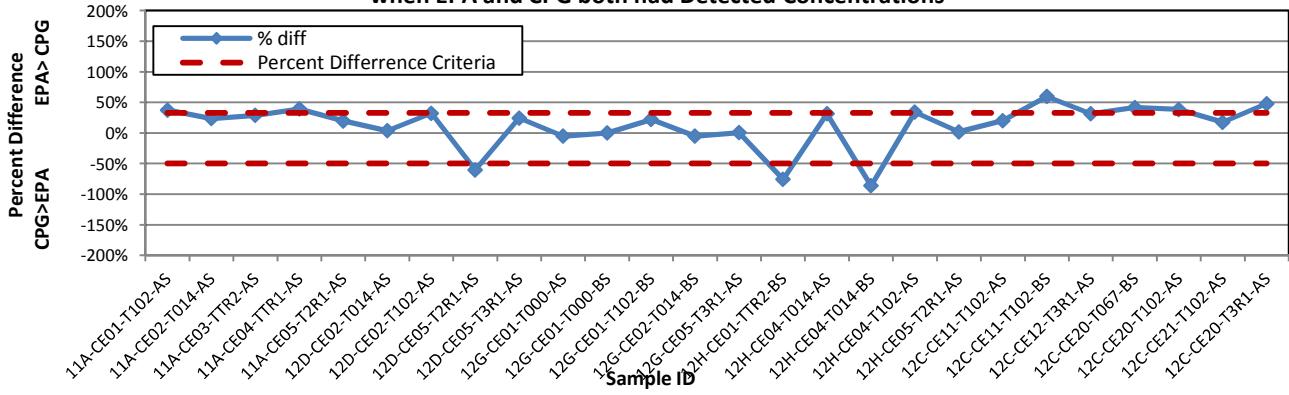


Figure 28a: Line Plot of Benzo[a]pyrene Concentrations

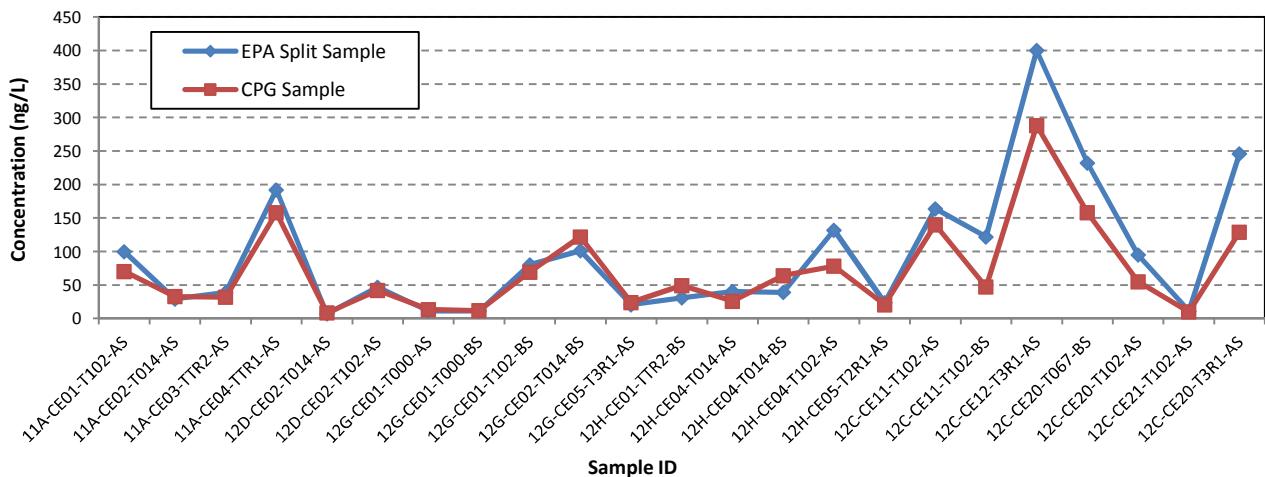


Figure 28b: Bivariate Plot of Benzo[a]pyrene Concentrations

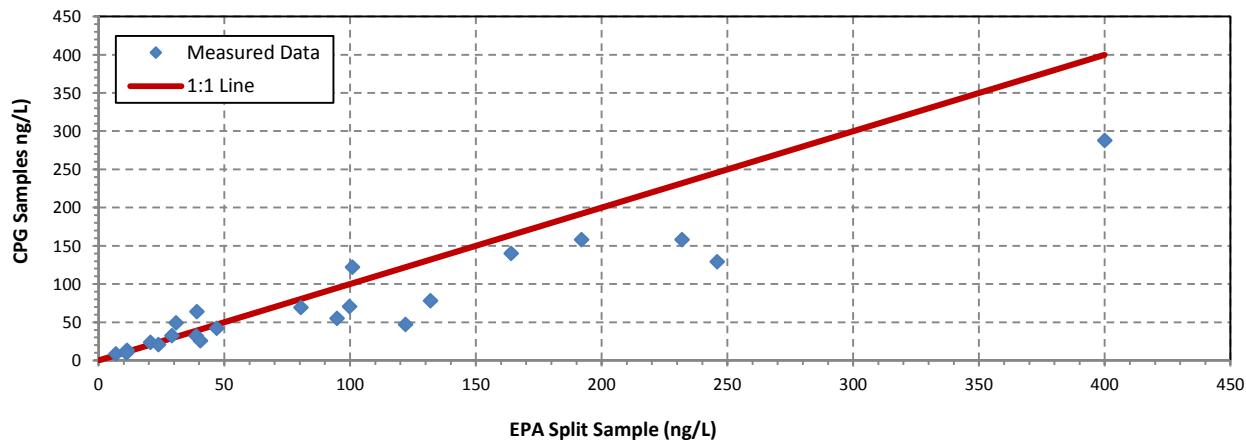


Figure 28c: Line Plot of Benzo[a]pyrene Percent Differences when EPA and CPG both had Detected Concentrations

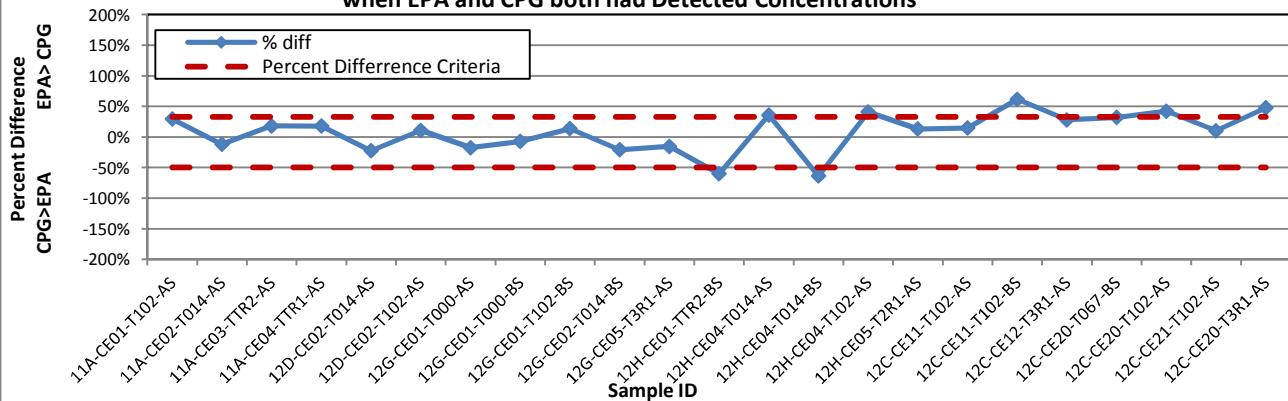


Figure 29a: Line Plot of Chrysene Concentrations

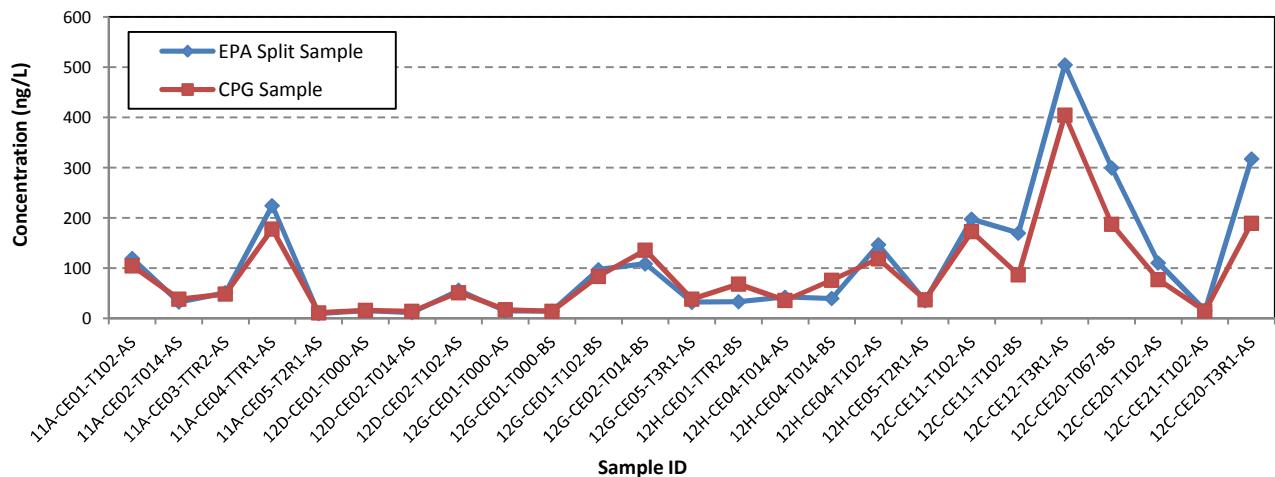


Figure 29b: Bivariate Plot of Chrysene Concentrations

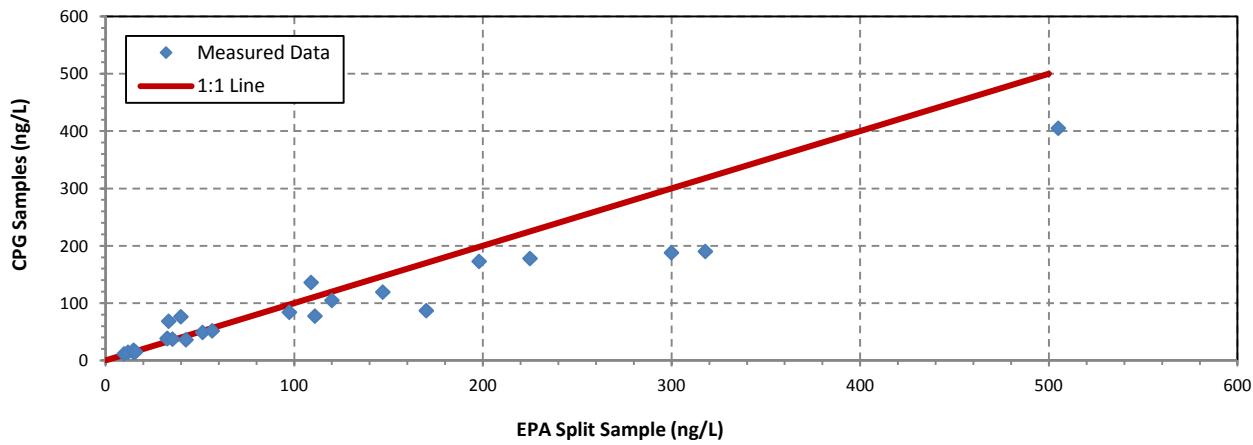


Figure 29c: Line Plot of Chrysene Percent Differences when EPA and CPG both had Detected Concentrations

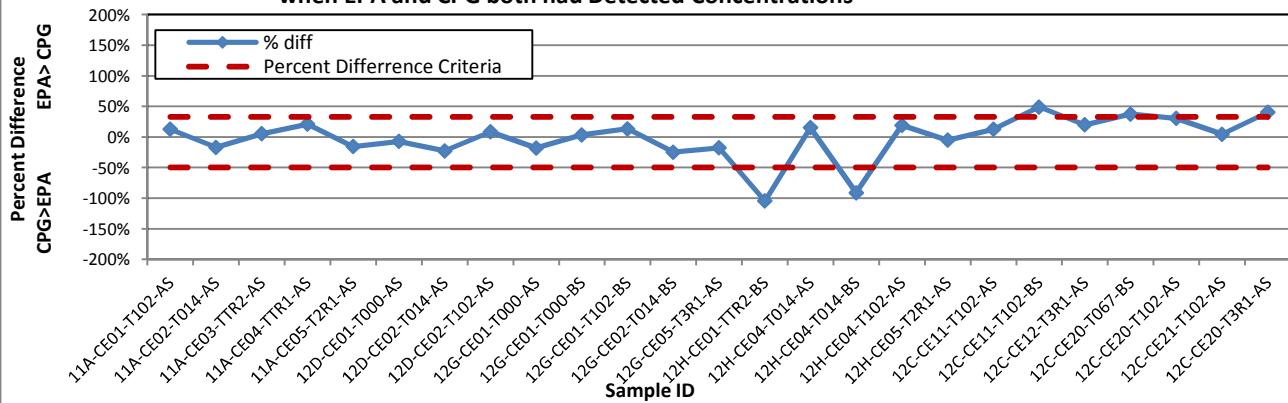


Figure 30a: Line Plot of Benzo[b]fluoranthene Concentrations

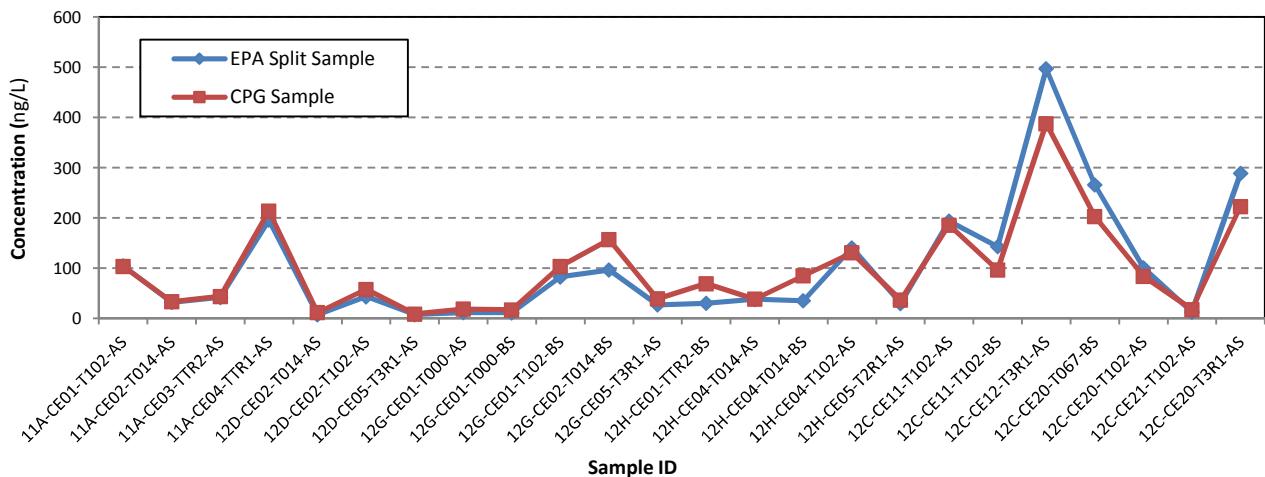


Figure 30b: Bivariate Plot of Benzo[b]fluoranthene Concentrations

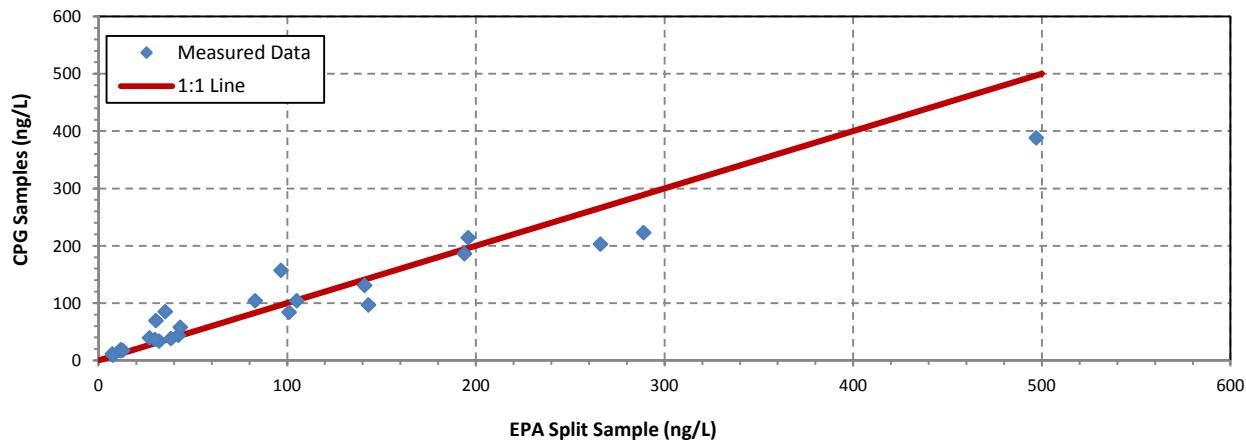


Figure 30c: Line Plot of Benzo[b]fluoranthene Percent Differences when EPA and CPG both had Detected Concentrations

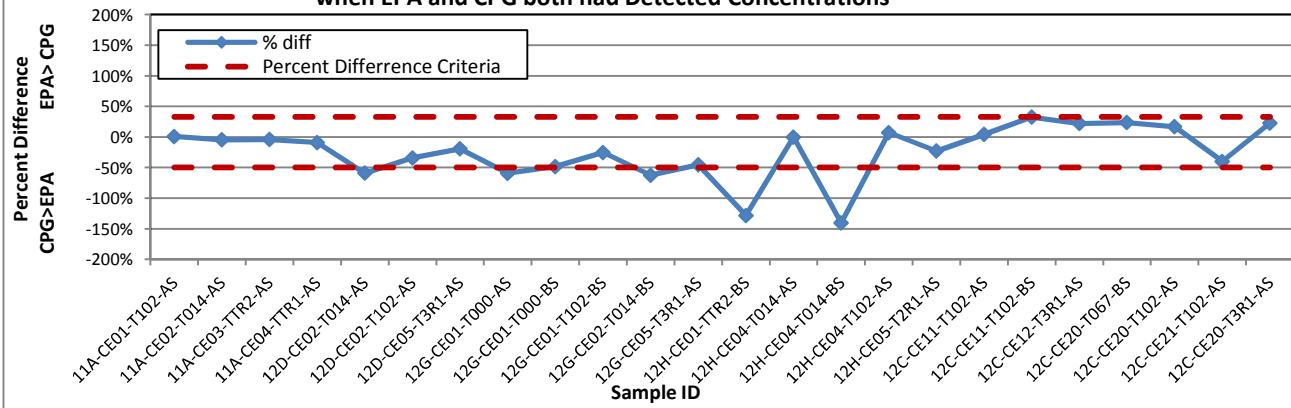


Figure 31a: Line Plot of Indeno[1,2,3-cd]pyrene Concentrations

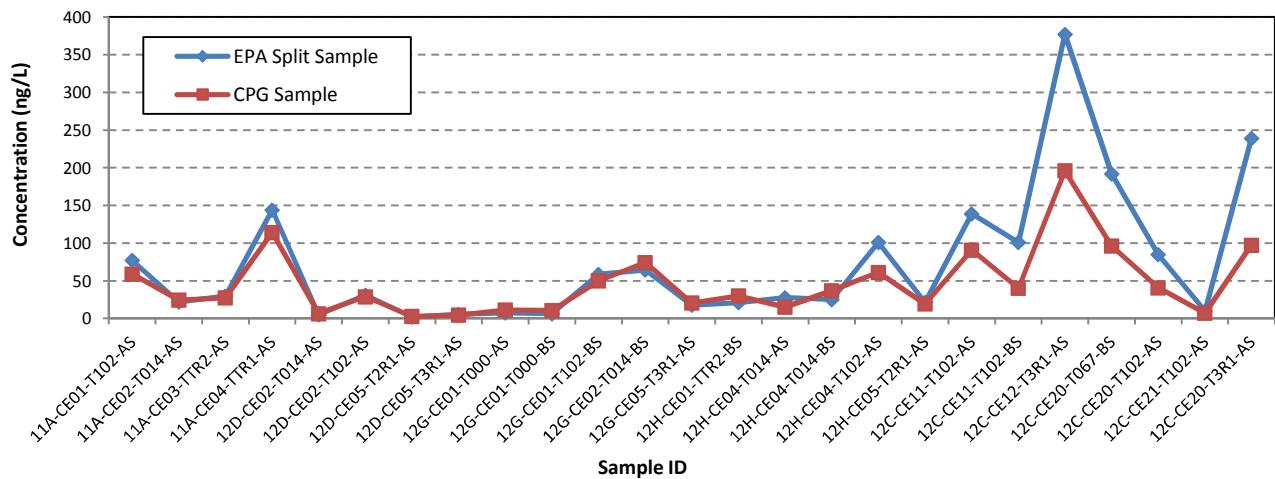


Figure 31b: Bivariate Plot of Indeno[1,2,3-cd]pyrene Concentrations

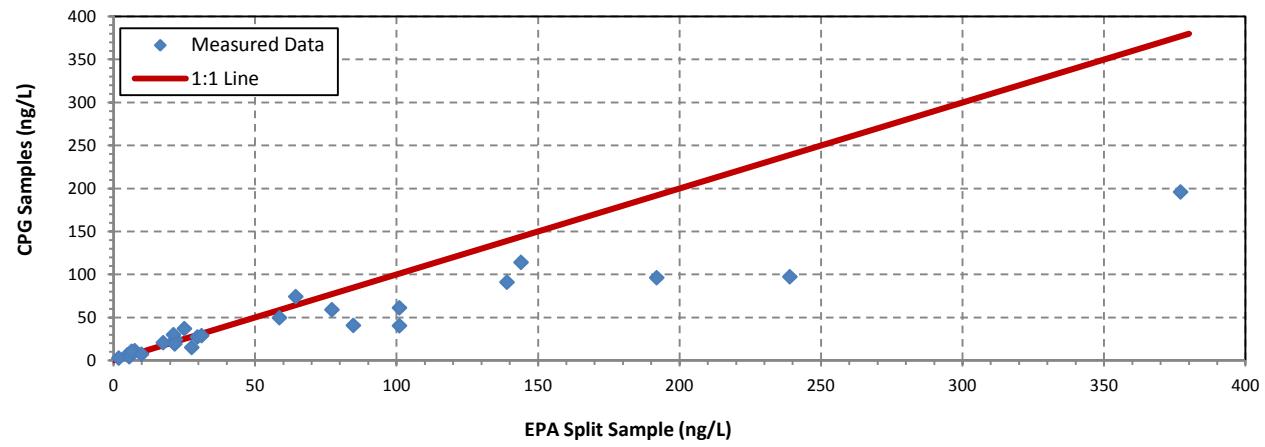


Figure 31c: Line Plot of Indeno[1,2,3-cd]pyrene Percent Differences when EPA and CPG both had Detected Concentrations

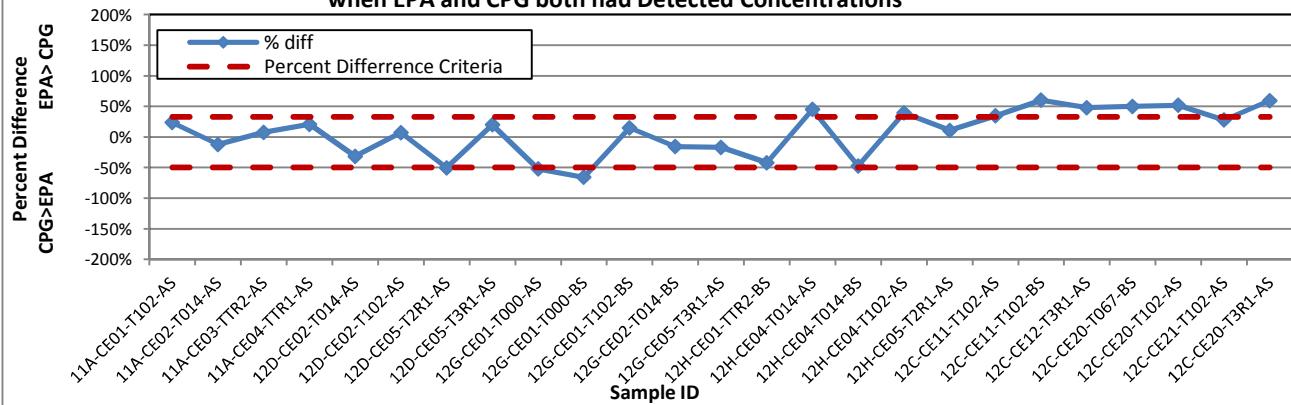


Figure 32a: Line Plot of Total Arsenic Concentrations

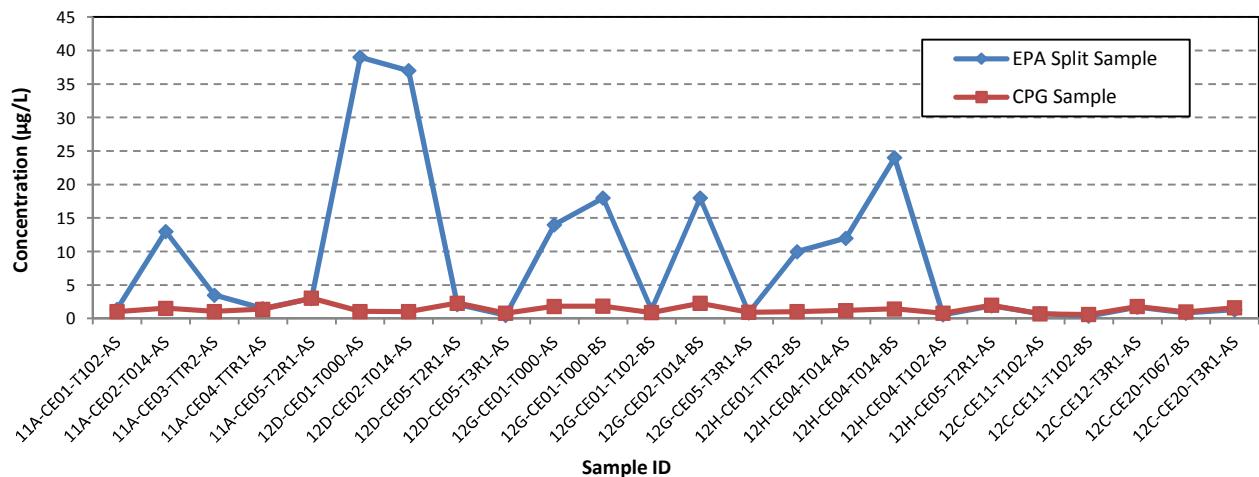


Figure 32b: Bivariate Plot of Total Arsenic Concentrations

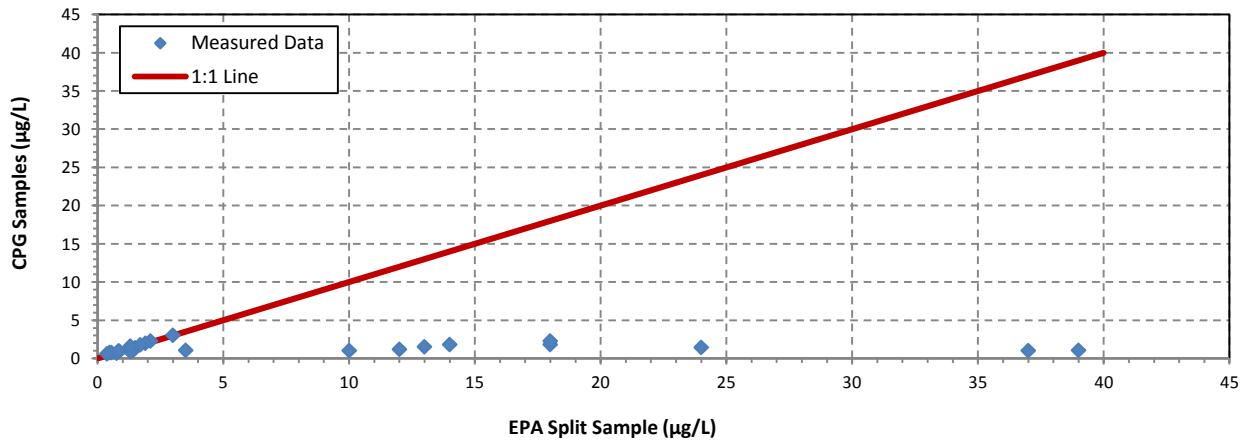


Figure 32c: Line Plot of Total Arsenic Percent Differences when EPA and CPG both had Detected Concentrations

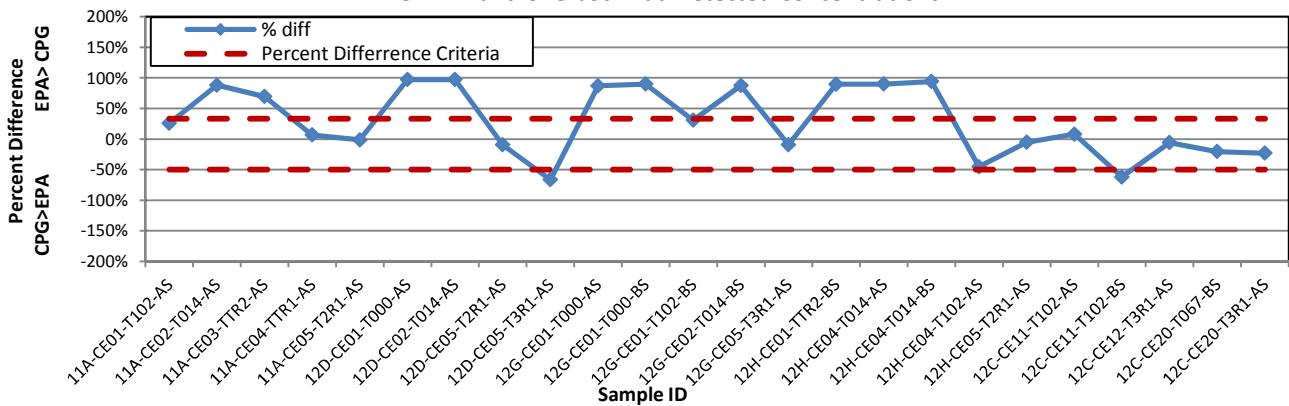


Figure 33a: Line Plot of Dissolved Arsenic Concentrations

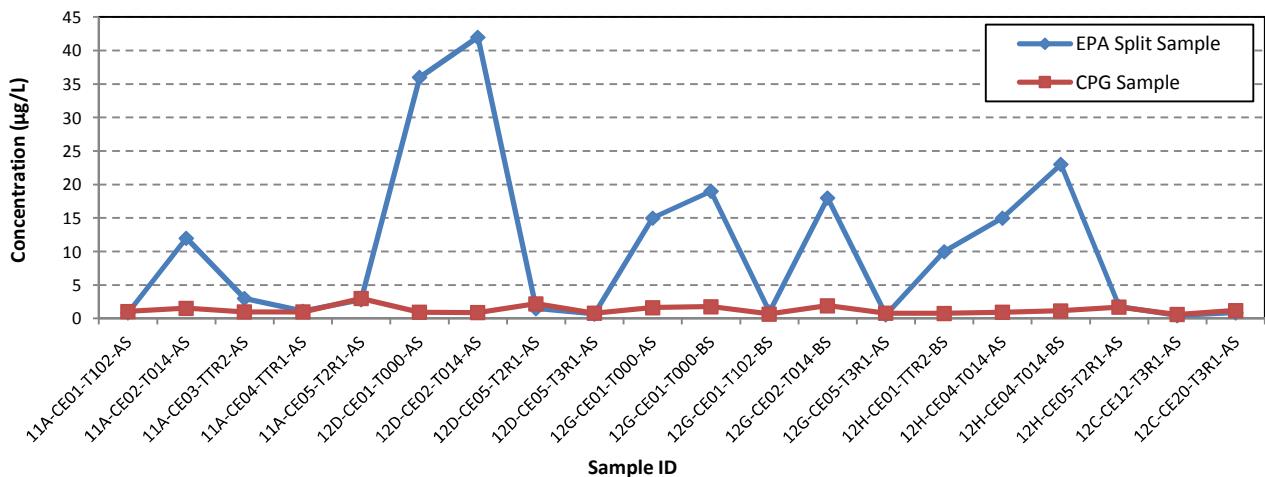


Figure 33b: Bivariate Plot of Dissolved Arsenic Concentrations

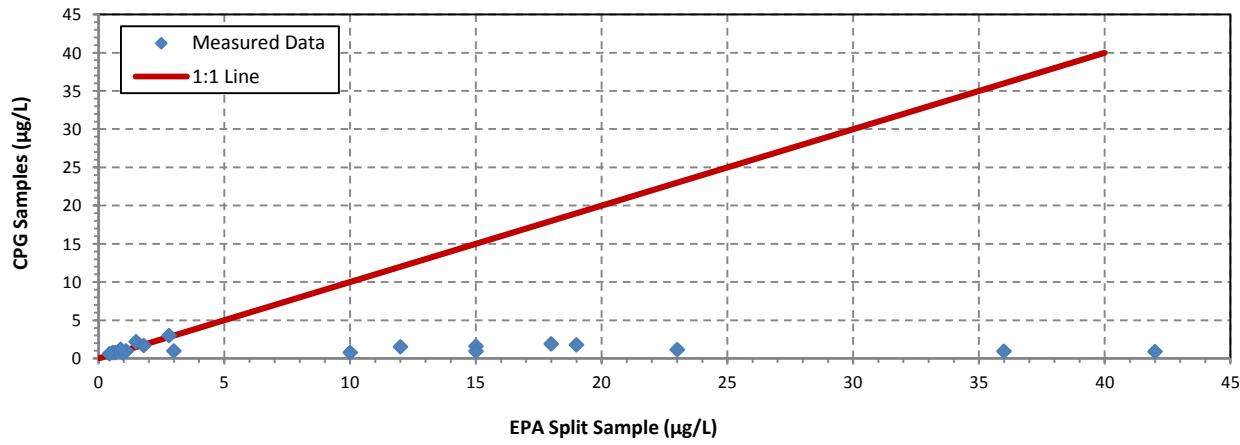


Figure 33c: Line Plot of Dissolved Arsenic Percent Differences when EPA and CPG both had Detected Concentrations

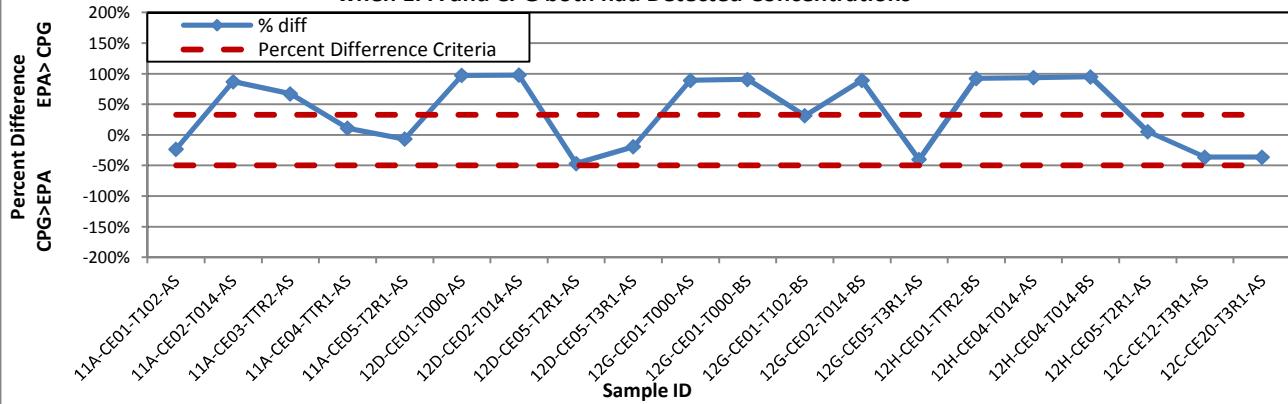


Figure 34a: Line Plot of Total Barium Concentrations

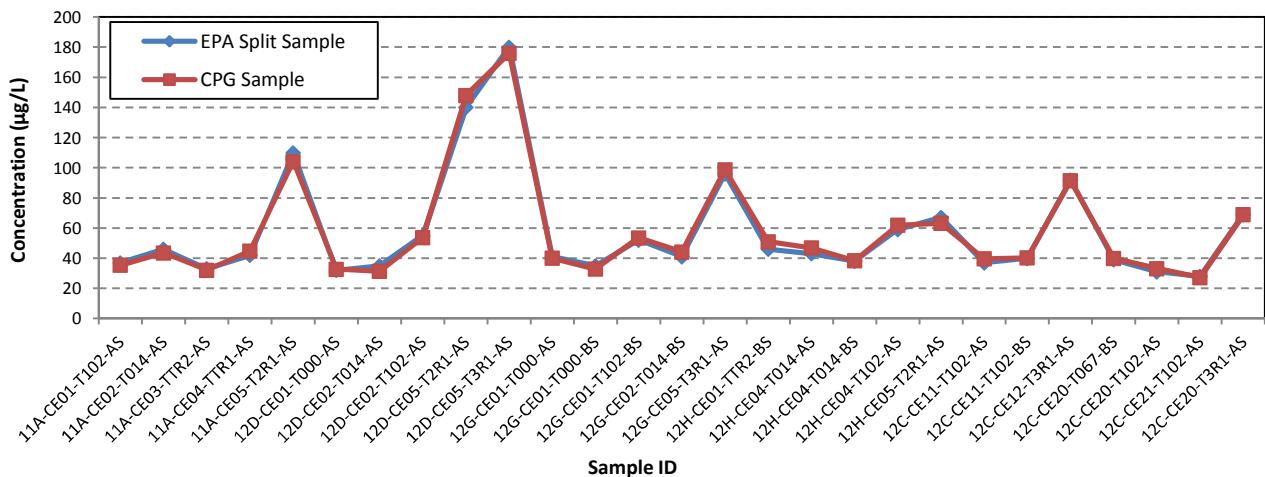


Figure 34b: Bivariate Plot of Total Barium Concentrations

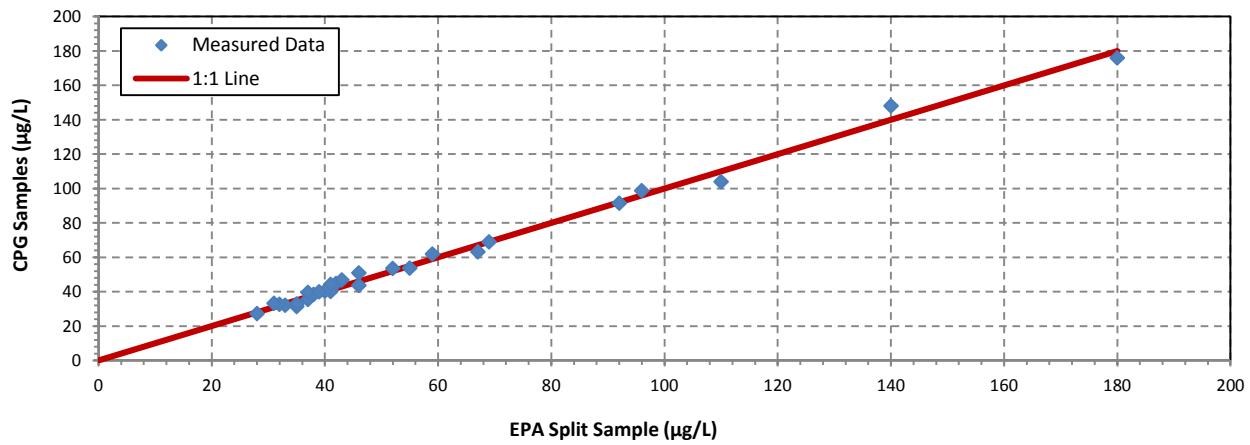


Figure 34c: Line Plot of Total Barium Percent Differences when EPA and CPG both had Detected Concentrations

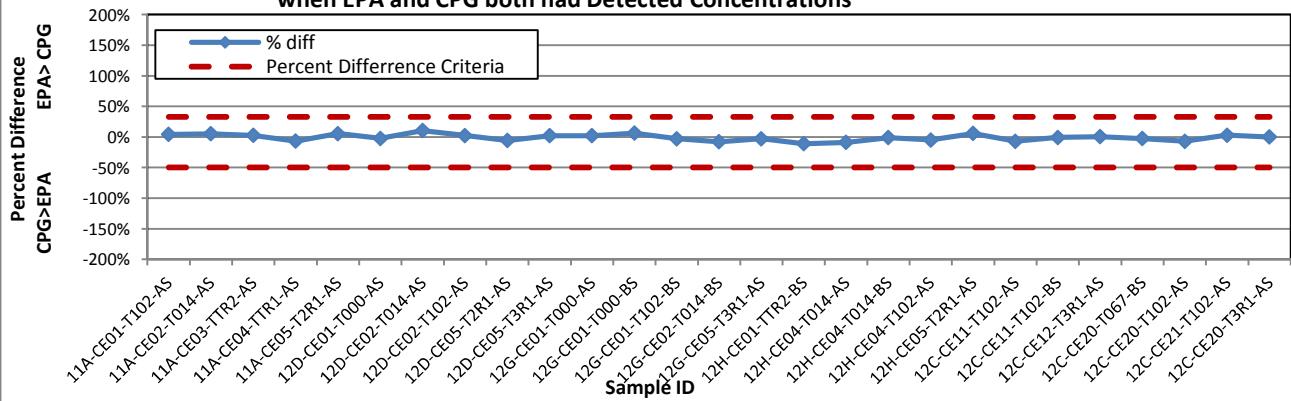


Figure 35a: Line Plot of Total Chromium Concentrations

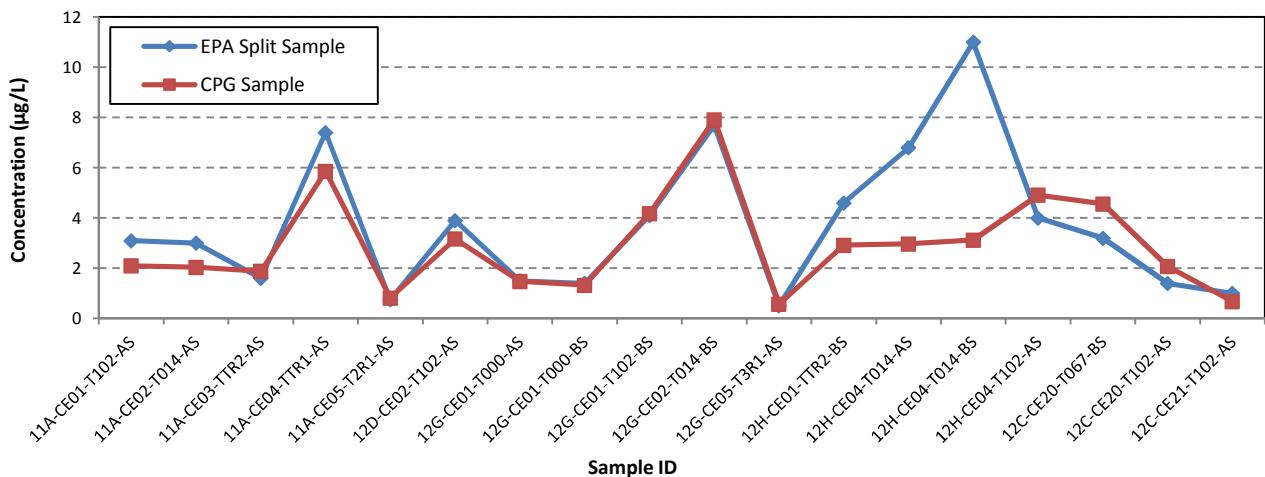


Figure 35b: Bivariate Plot of Total Chromium Concentrations

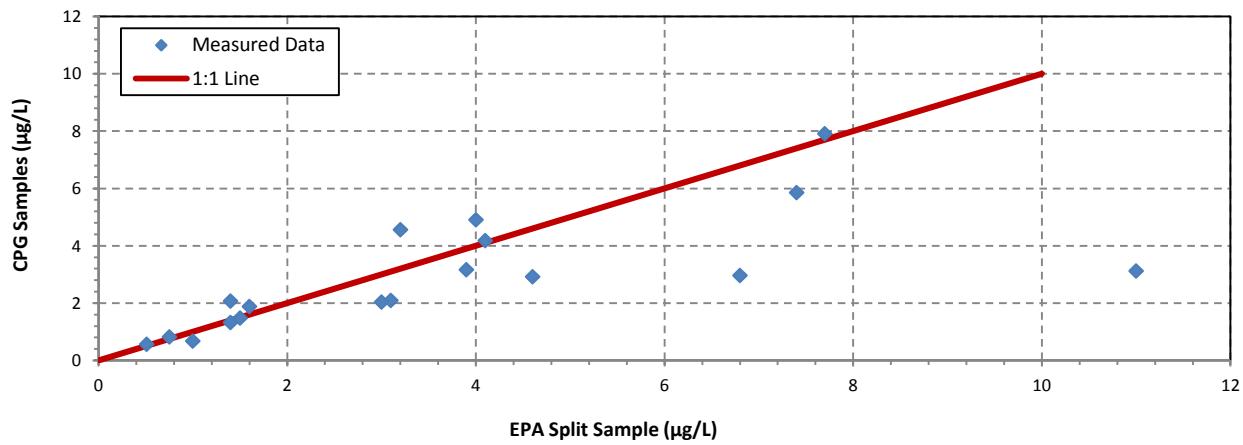


Figure 35c: Line Plot of Total Chromium Percent Differences when EPA and CPG both had Detected Concentrations

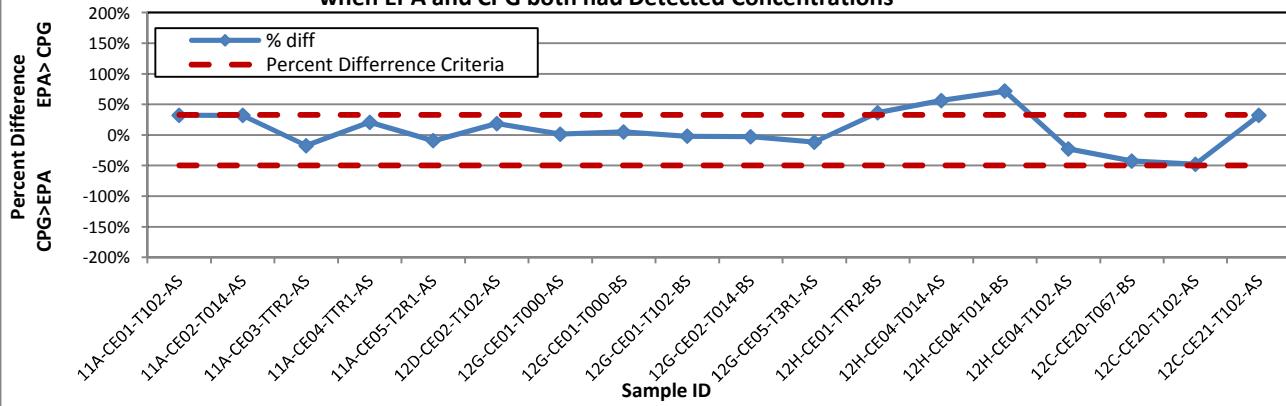


Figure 36a: Line Plot of Dissolved Chromium Concentrations

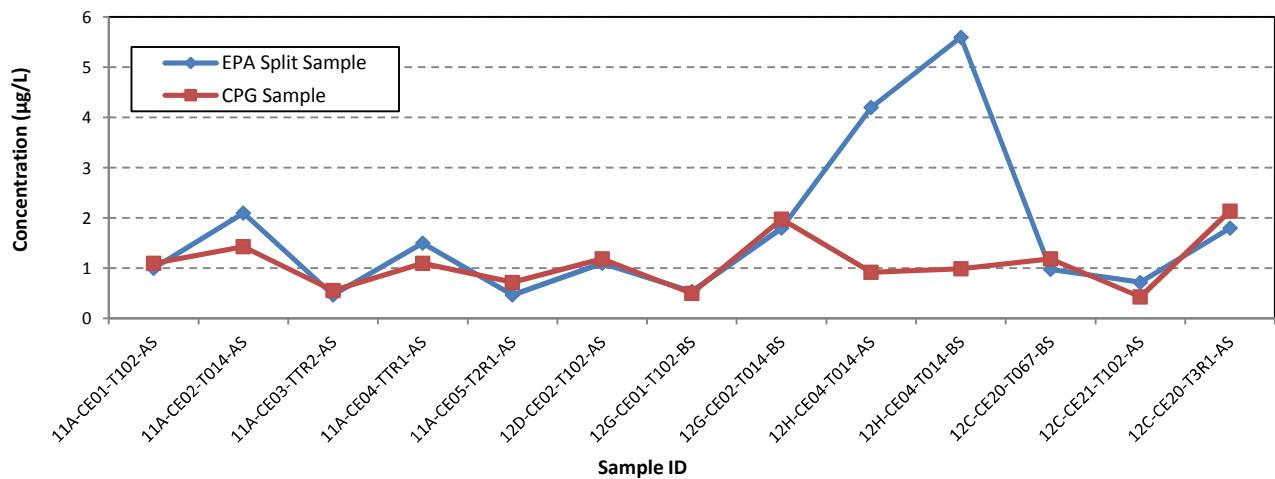


Figure 36b: Bivariate Plot of Dissolved Chromium Concentrations

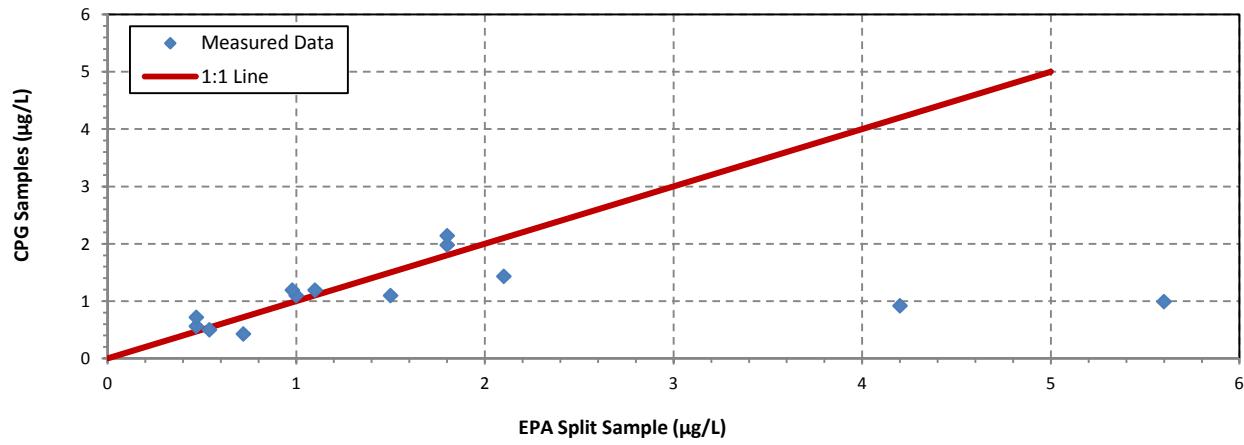


Figure 36c: Line Plot of Dissolved Chromium Percent Differences when EPA and CPG both had Detected Concentrations

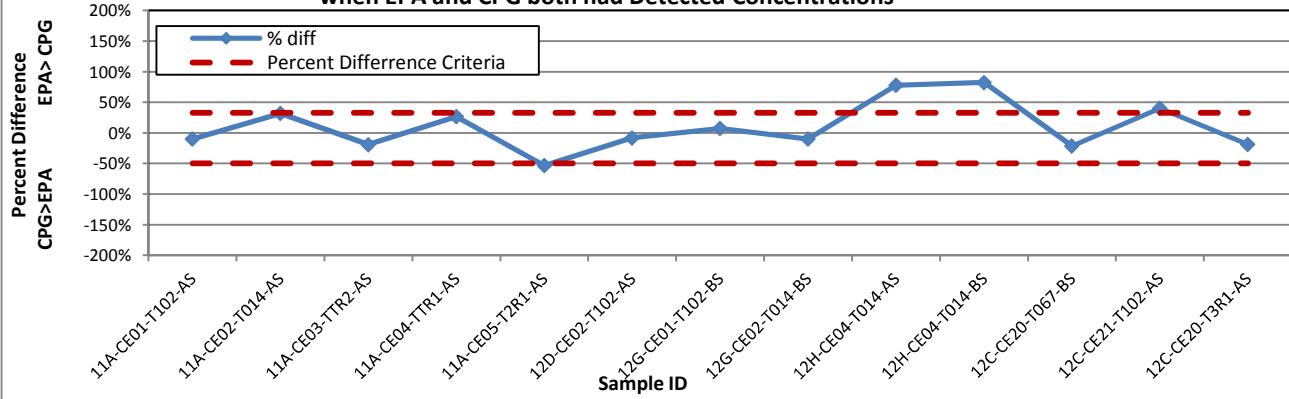


Figure 37a: Line Plot of Total Copper Concentrations

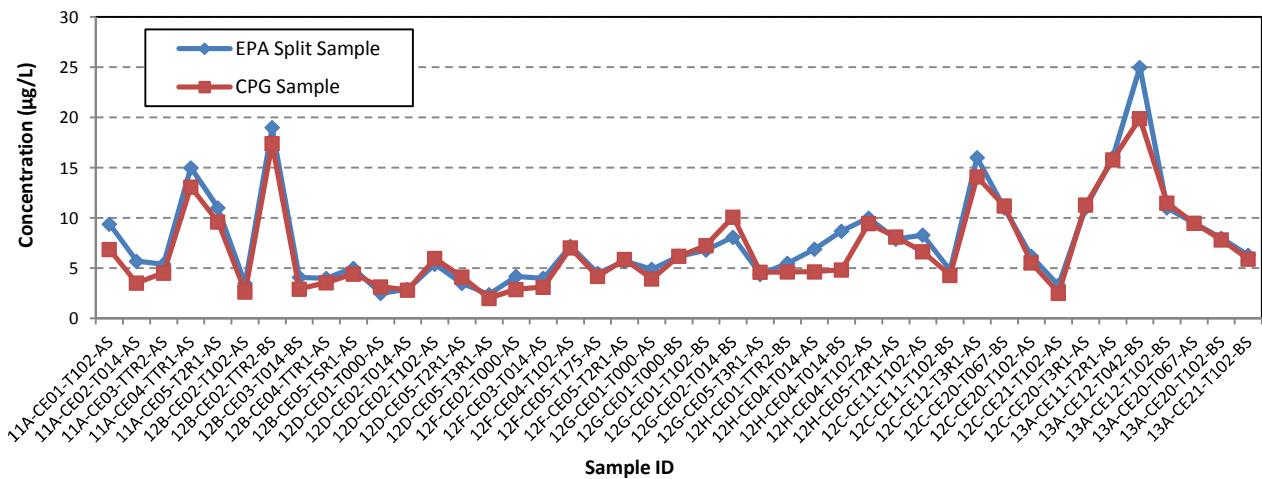


Figure 37b: Bivariate Plot of Total Copper Concentrations

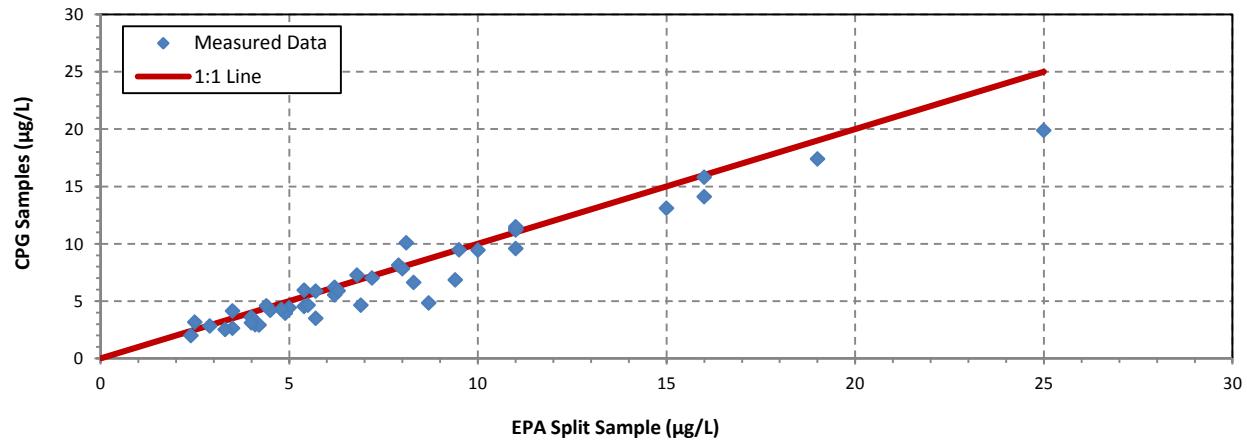
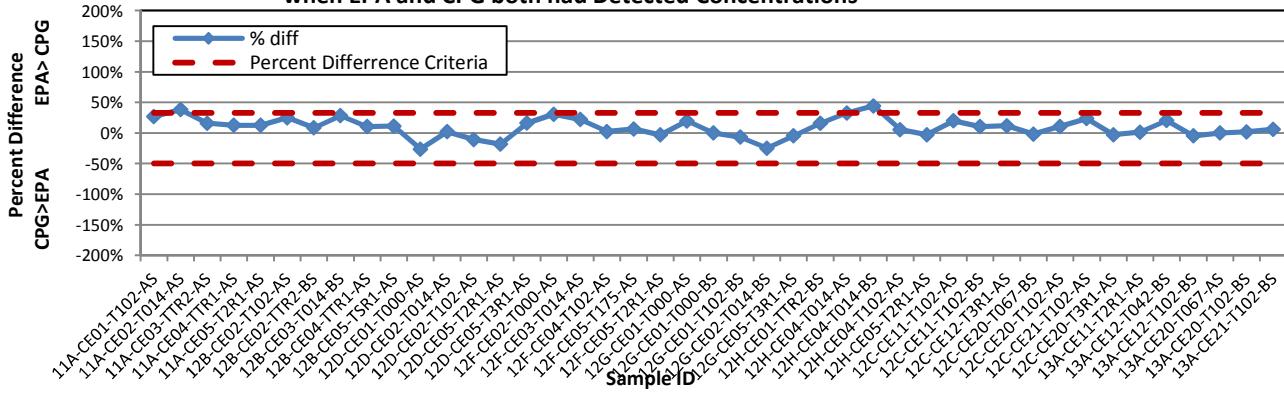


Figure 37c: Line Plot of Total Copper Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total Copper Concentrations

Figure 37

µg/L - microgram per liter

Figure 38a: Line Plot of Total Lead Concentrations

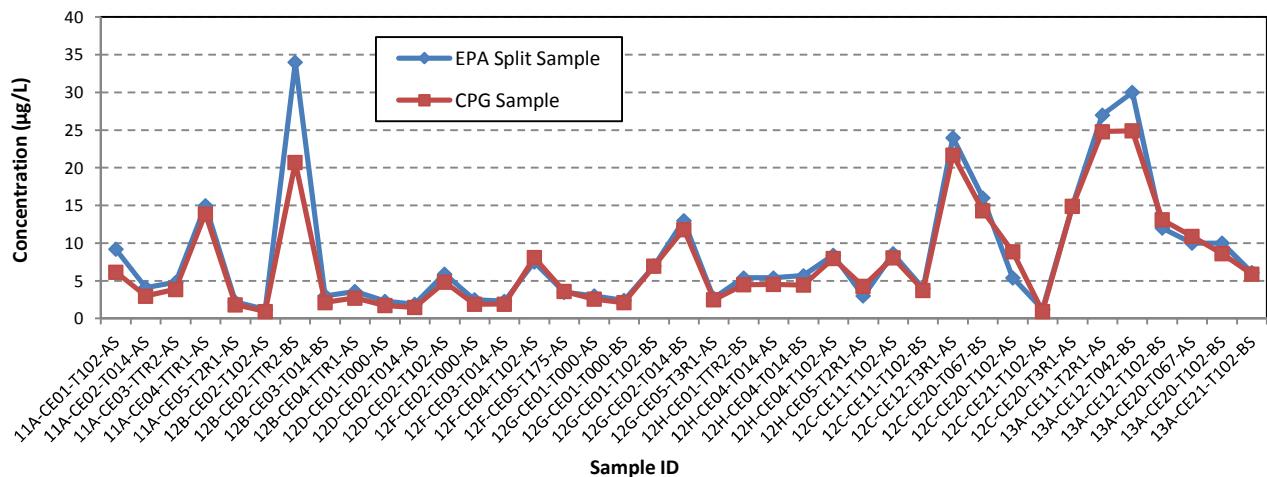


Figure 38b: Bivariate Plot of Total Lead Concentrations

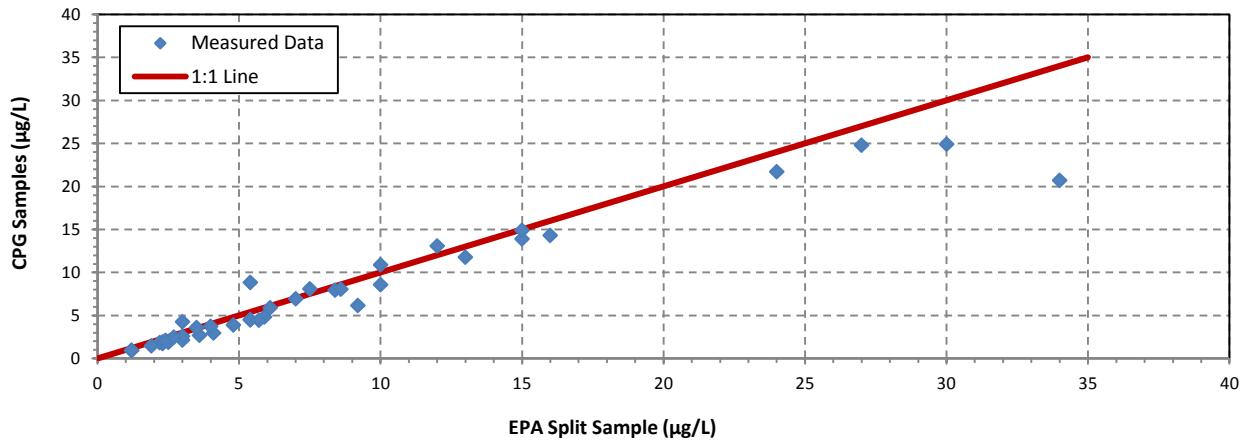
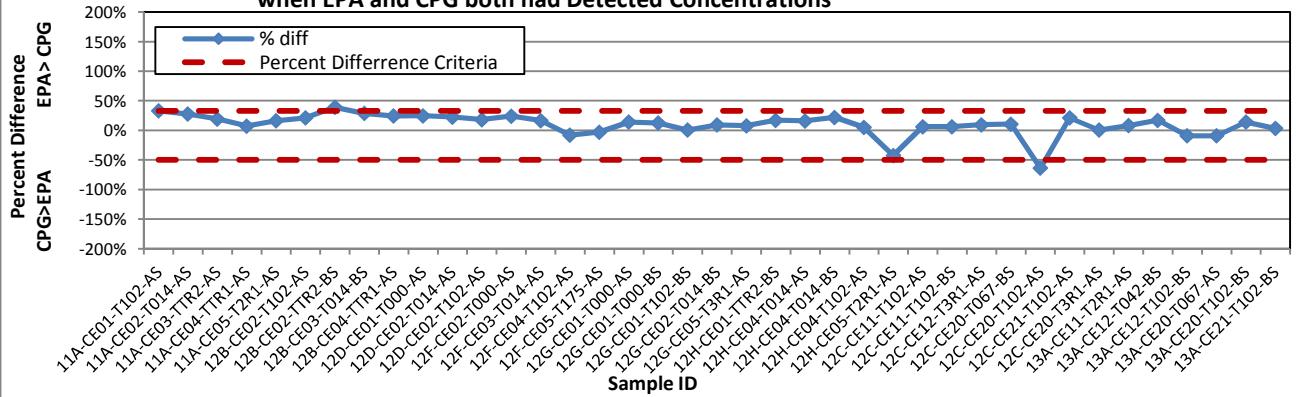


Figure 38c: Line Plot of Total Lead Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total Lead Concentrations

Figure 38

$\mu\text{g/L}$ - microgram per liter

Figure 39a: Line Plot of Dissolved Lead Concentrations

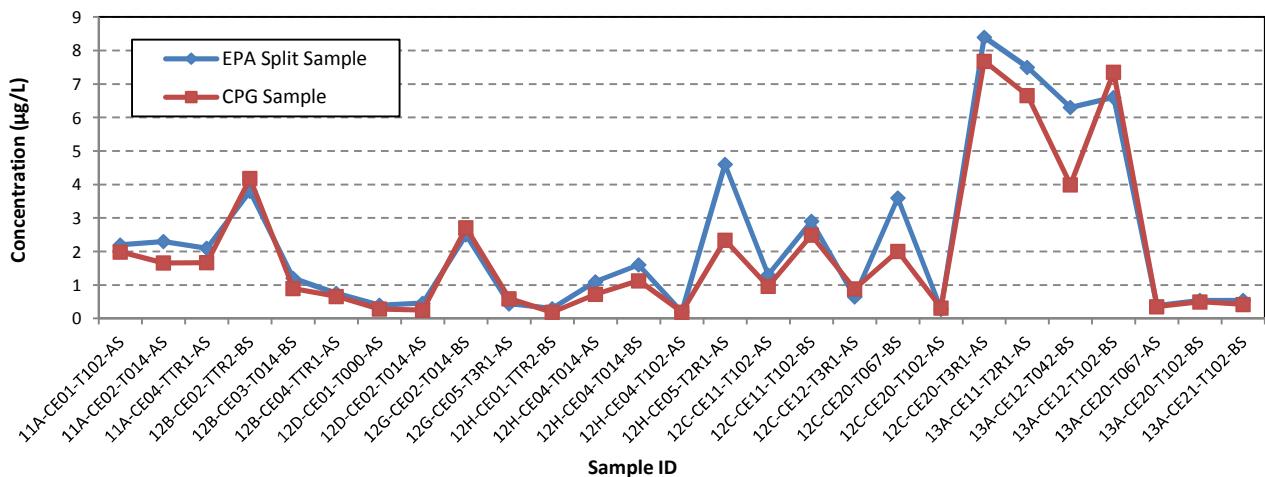


Figure 39b: Bivariate Plot of Dissolved Lead Concentrations

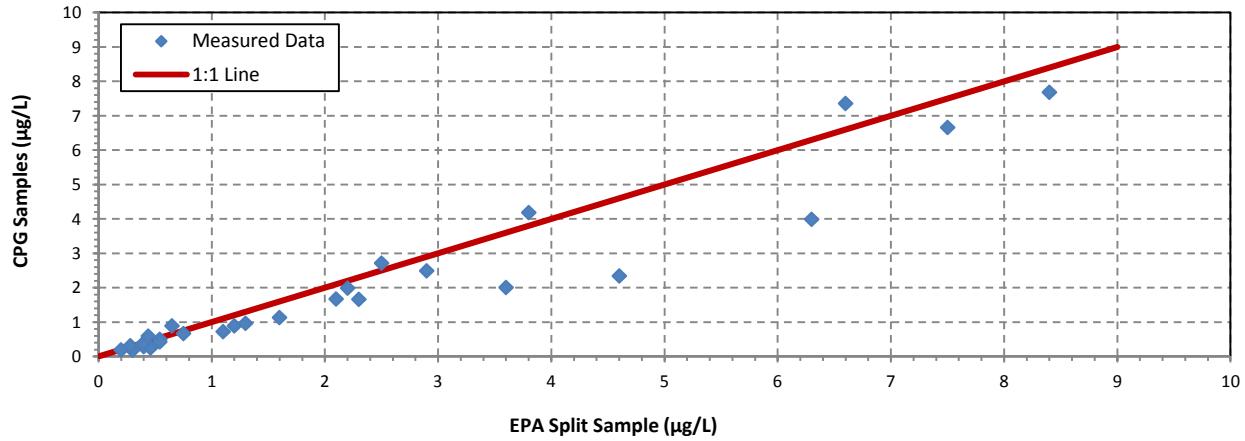


Figure 39c: Line Plot of Dissolved Lead Percent Differences when EPA and CPG both had Detected Concentrations

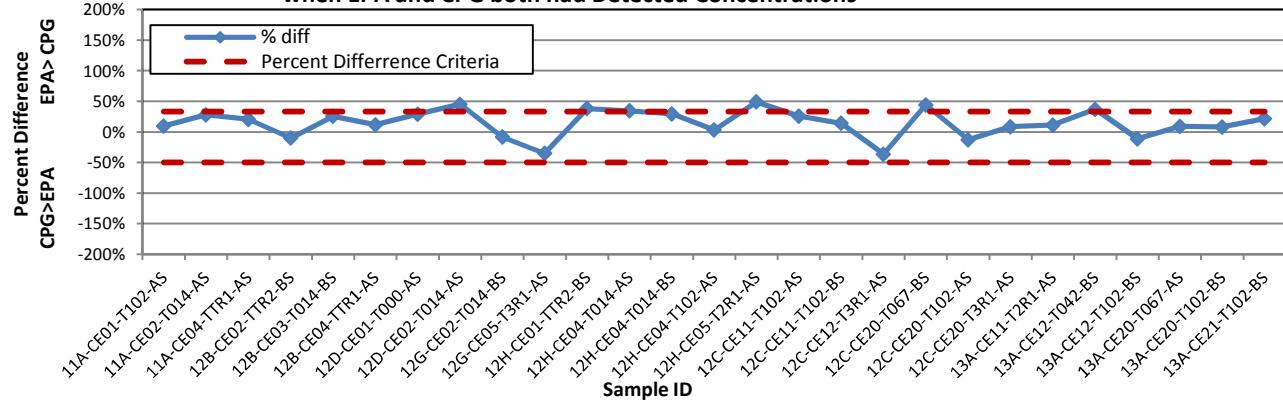


Figure 40a: Line Plot of Total Titanium Concentrations

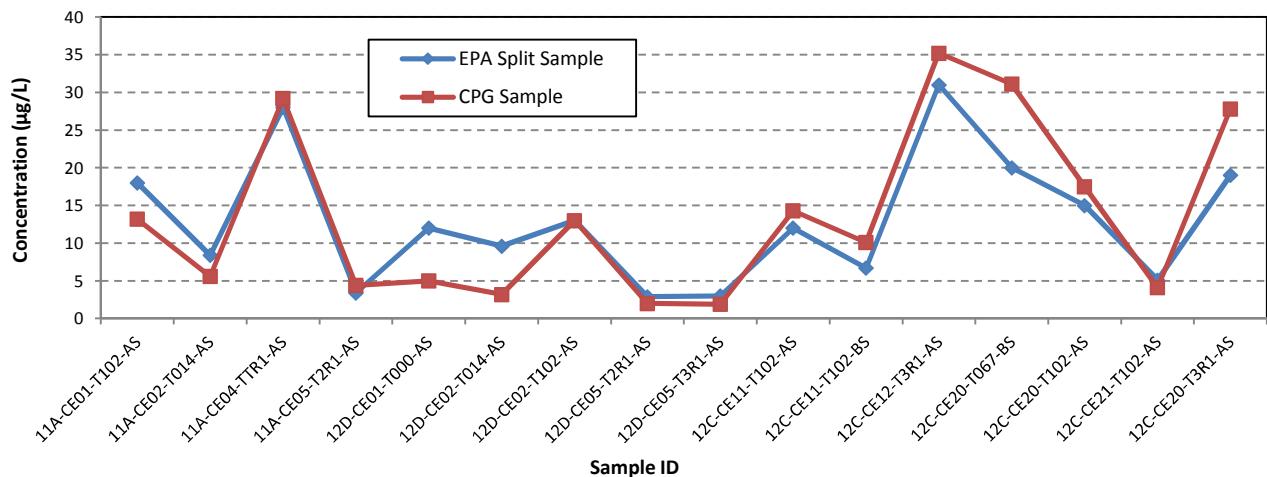


Figure 40b: Bivariate Plot of Total Titanium Concentrations

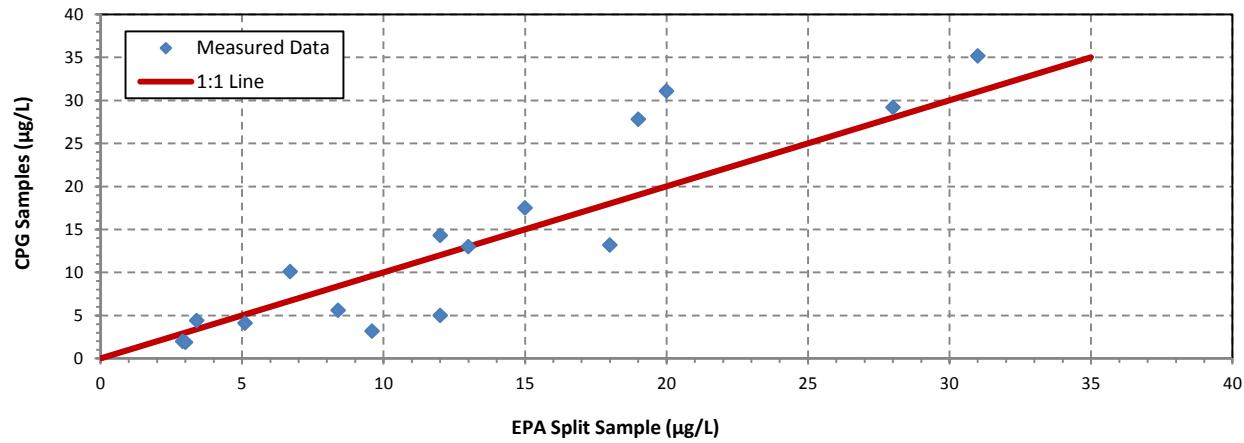
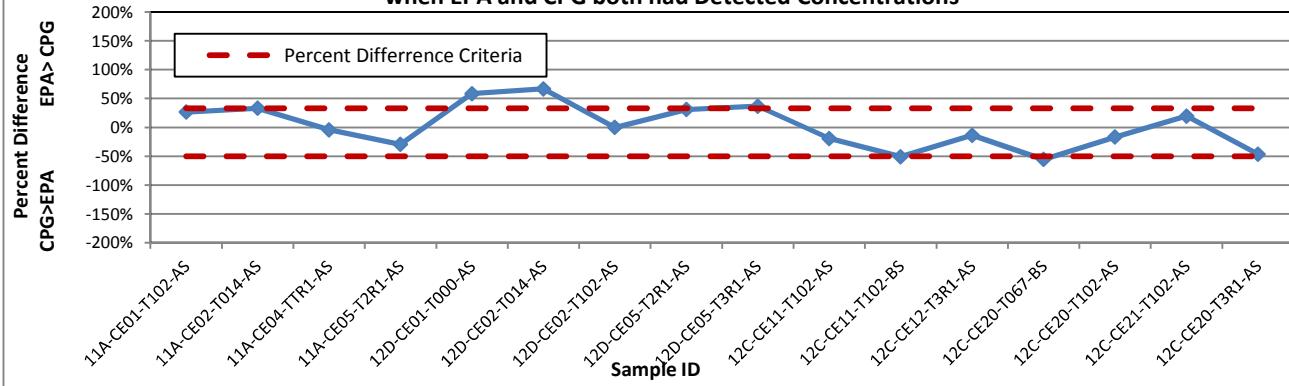


Figure 40c: Line Plot of Total Titanium Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total Titanium Concentrations

Figure 40

$\mu\text{g/L}$ - microgram per liter

Figure 41a: Line Plot of Total Zinc Concentrations

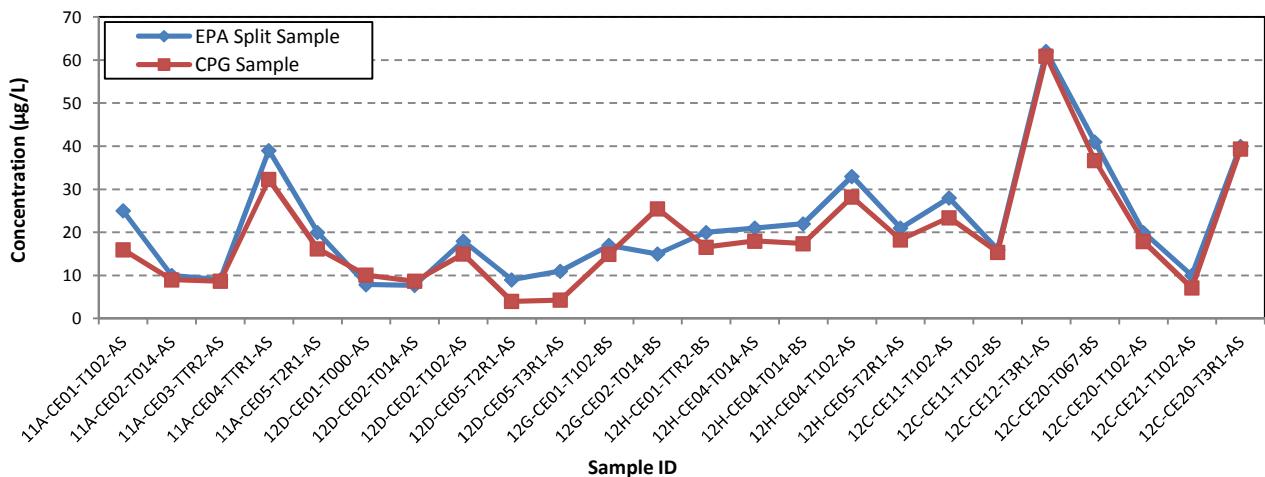


Figure 41b: Bivariate Plot of Total Zinc Concentrations

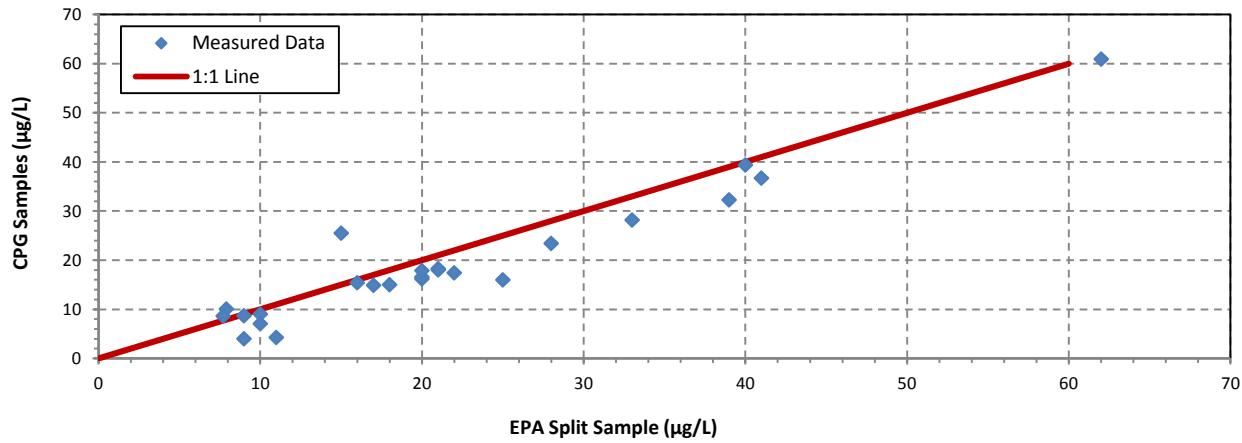


Figure 41c: Line Plot of Total Zinc Percent Differences when EPA and CPG both had Detected Concentrations

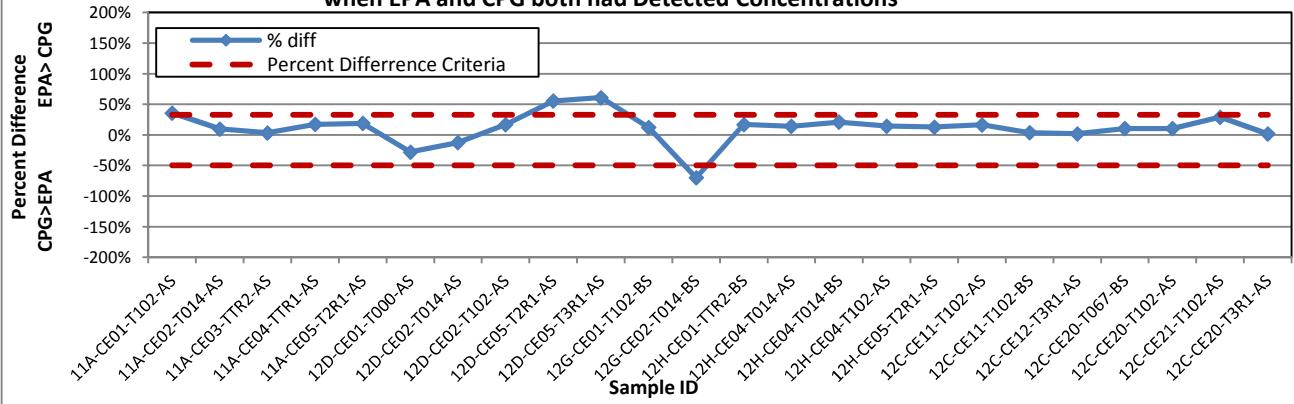


Figure 42a: Line Plot of Total Mercury Concentrations

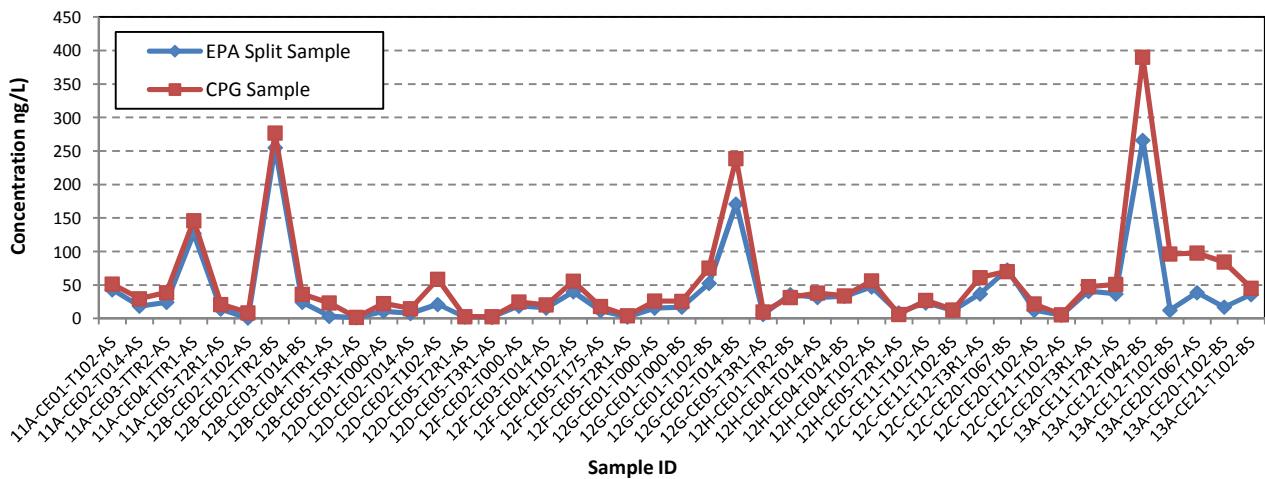


Figure 42b: Bivariate Plot of Total Mercury Concentrations

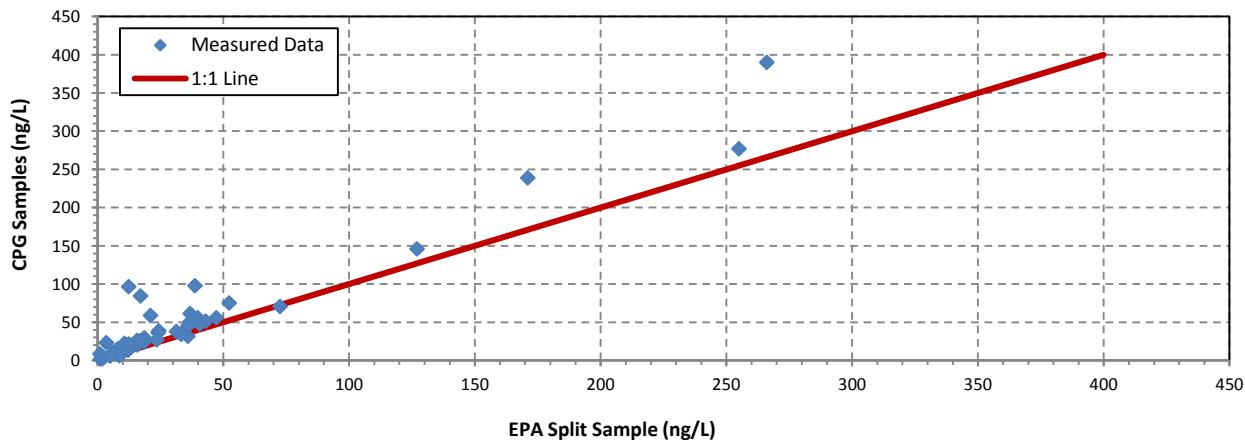
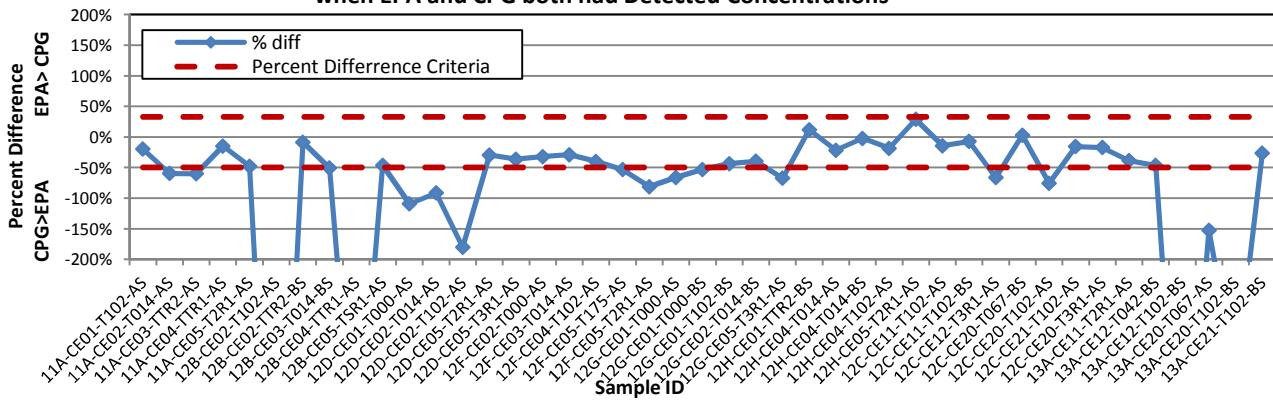


Figure 42c: Line Plot of Total Mercury Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total Mercury Concentrations

Figure 42

ng/L - nanogram per liter

Figure 43a: Line Plot of Dissolved Mercury Concentrations

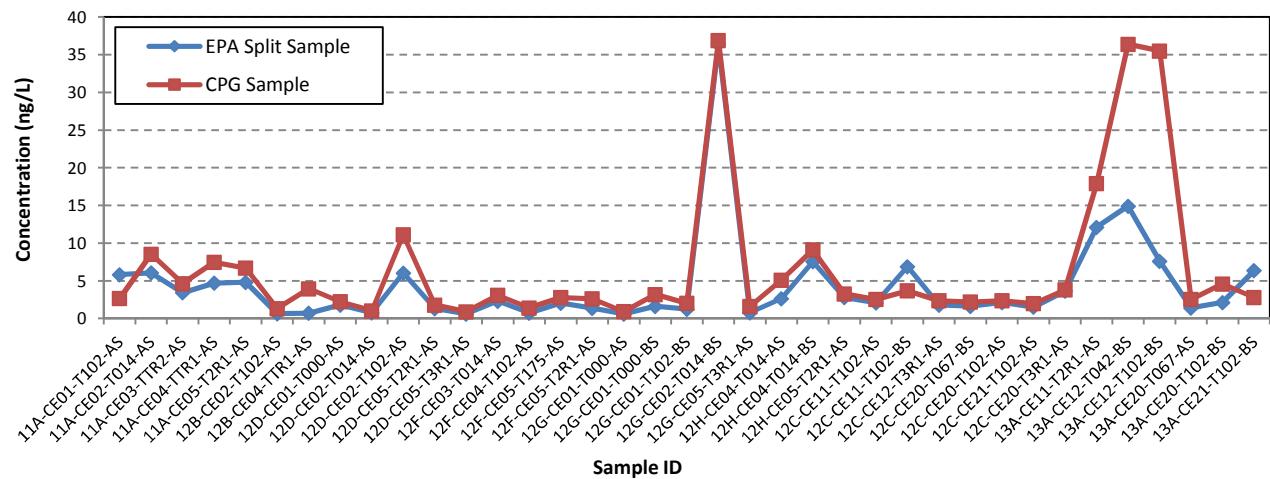


Figure 43b: Bivariate Plot of Dissolved Mercury Concentrations

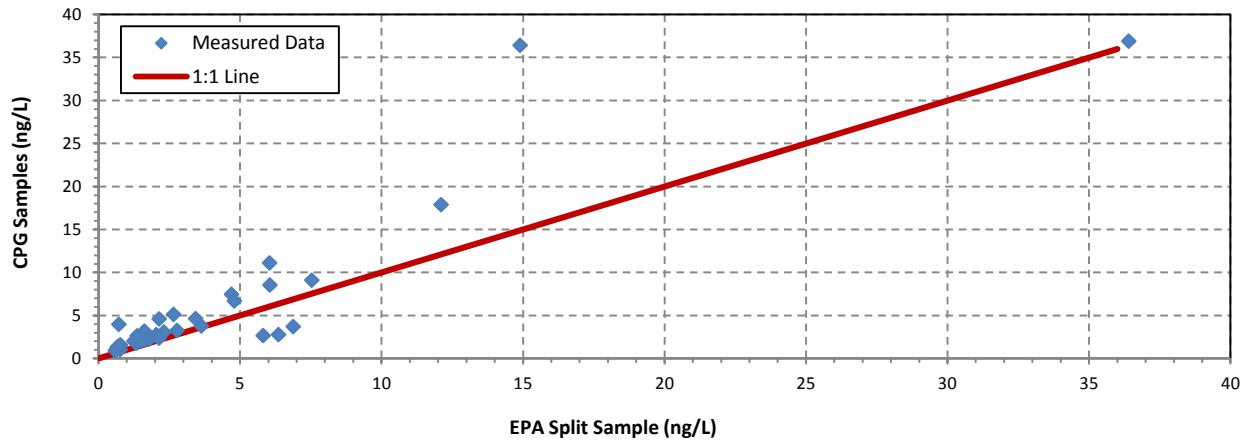


Figure 43c: Line Plot of Dissolved Mercury Percent Differences when EPA and CPG both had Detected Concentrations

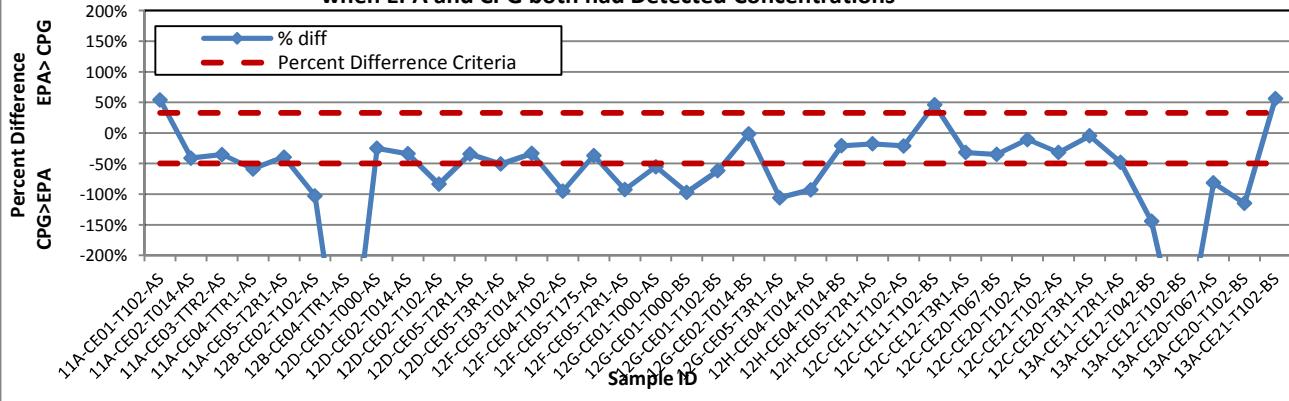


Figure 44a: Line Plot of Total Methyl Mercury Concentrations

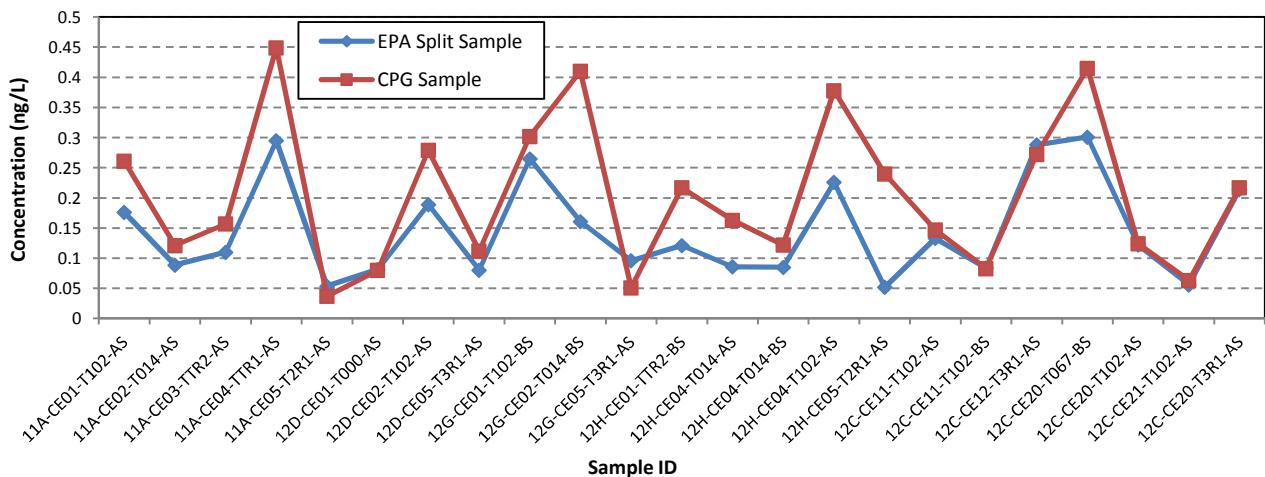


Figure 44b: Bivariate Plot of Total Methyl Mercury Concentrations

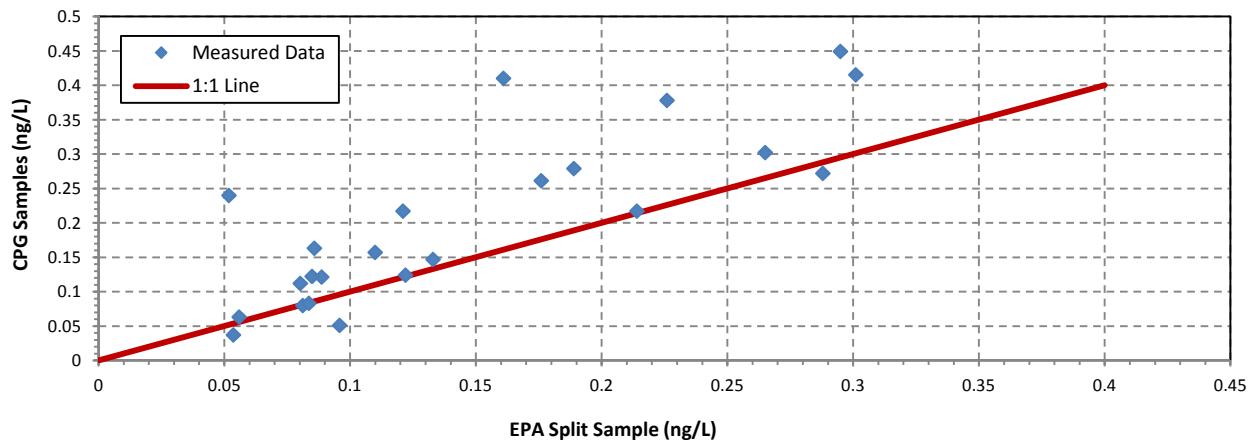


Figure 44c: Line Plot of Total Methyl Mercury Percent Differences when EPA and CPG both had Detected Concentrations

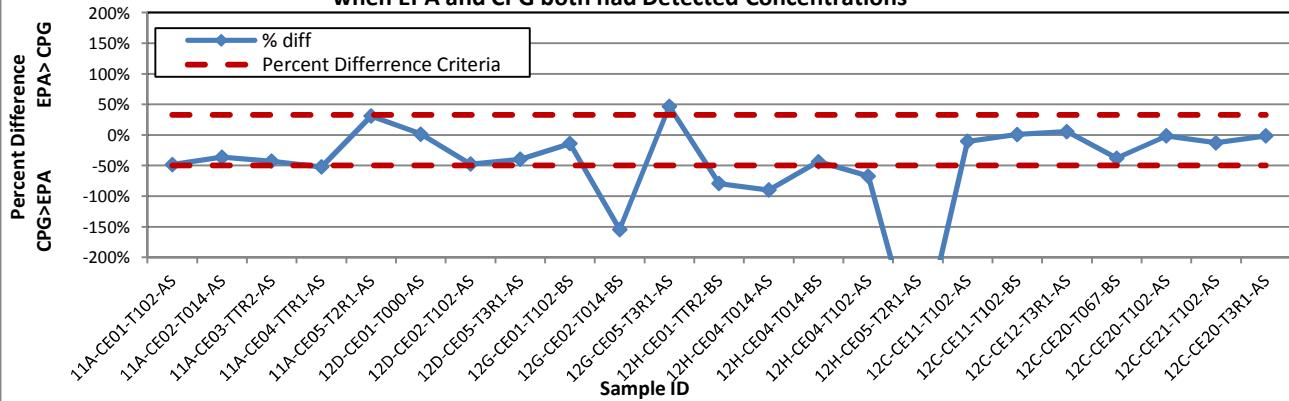


Figure 45a: Line Plot of Dissolved Methyl Mercury Concentrations

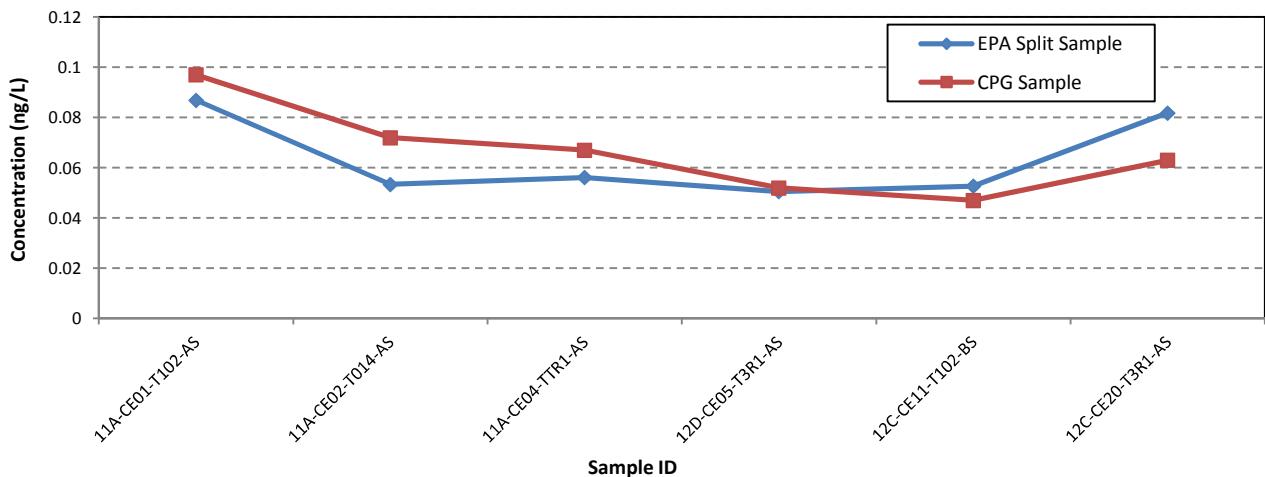


Figure 45b: Bivariate Plot of Dissolved Methyl Mercury Concentrations

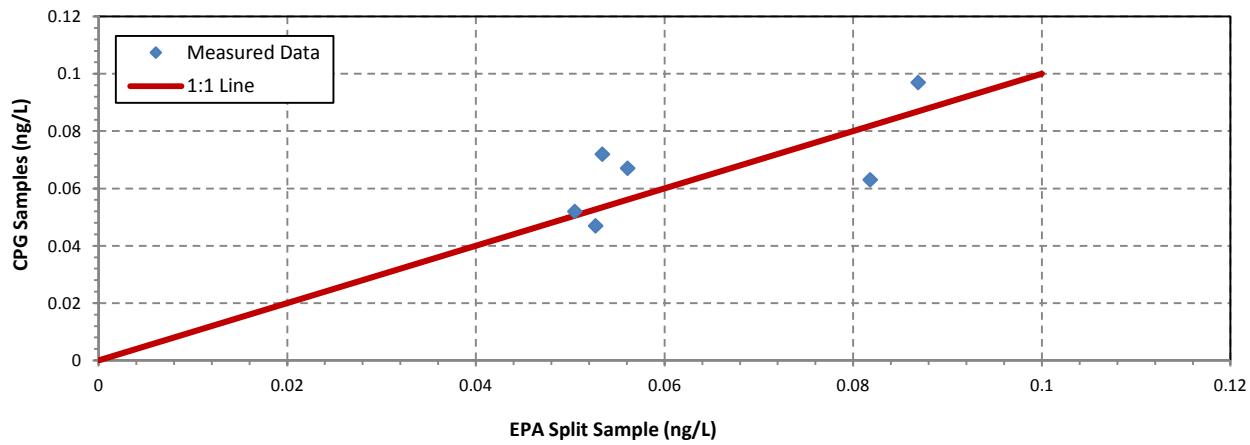


Figure 45c: Line Plot of Dissolved Methyl Mercury Percent Differences when EPA and CPG both had Detected Concentrations

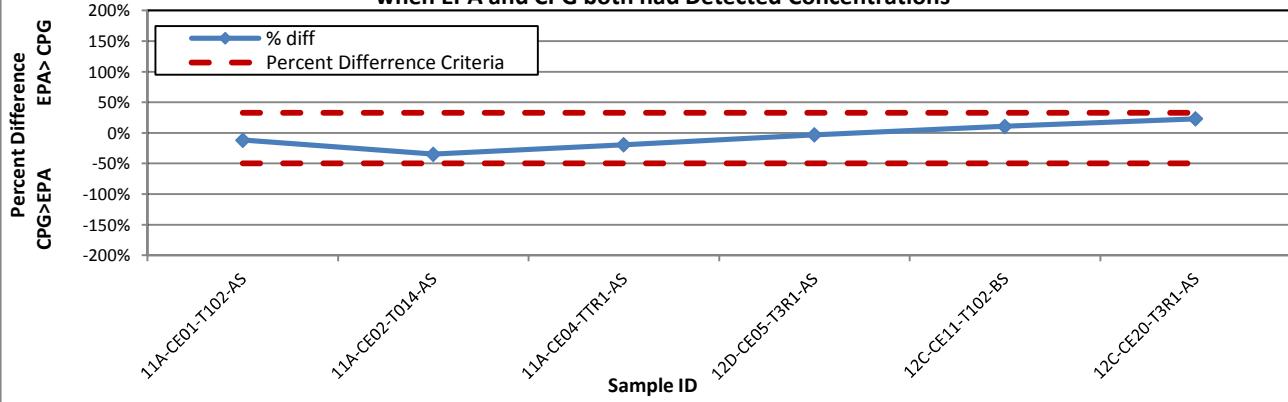


Figure 46a: Line Plot of Total Organic Carbon Concentrations

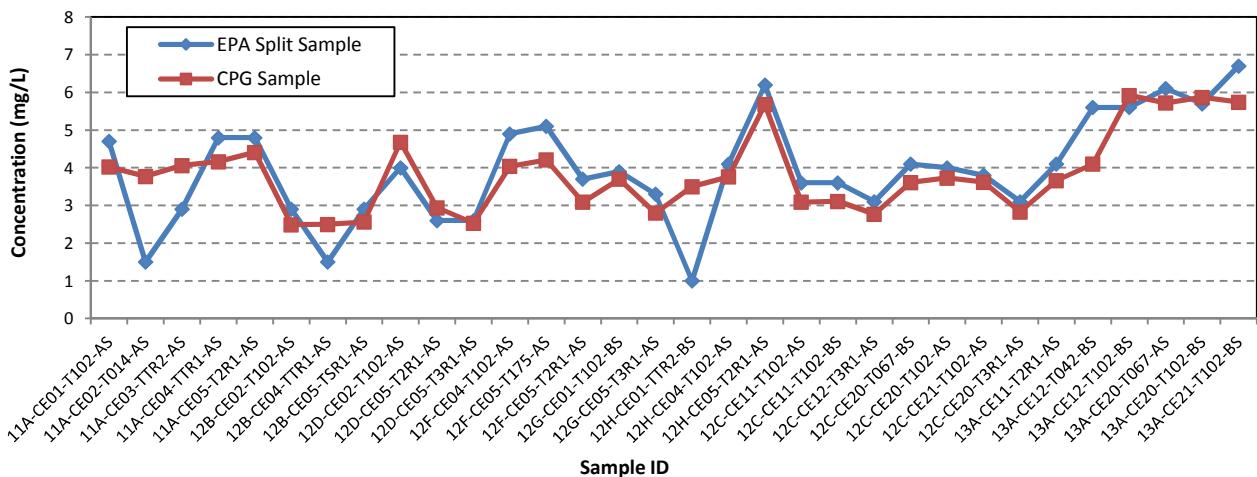


Figure 46b: Bivariate Plot of Total Organic Carbon Concentrations

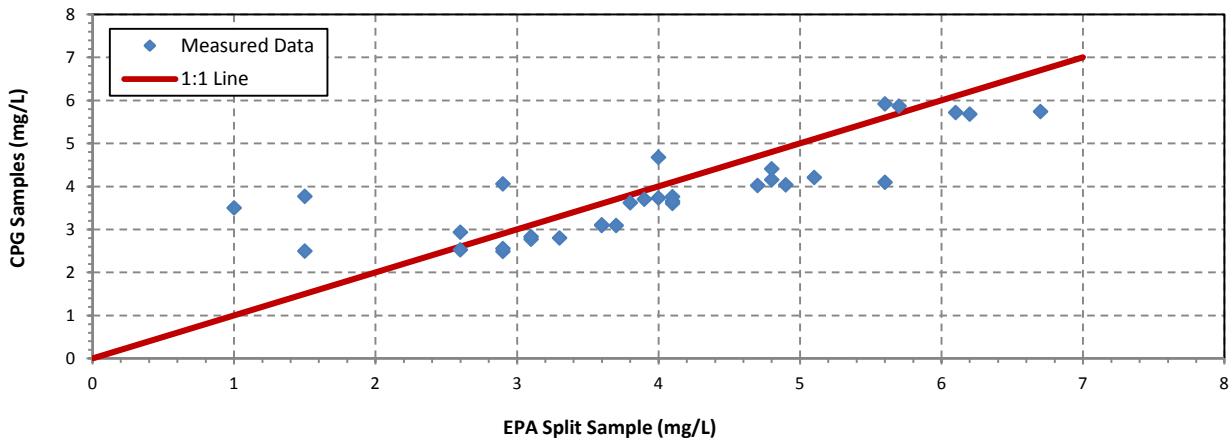
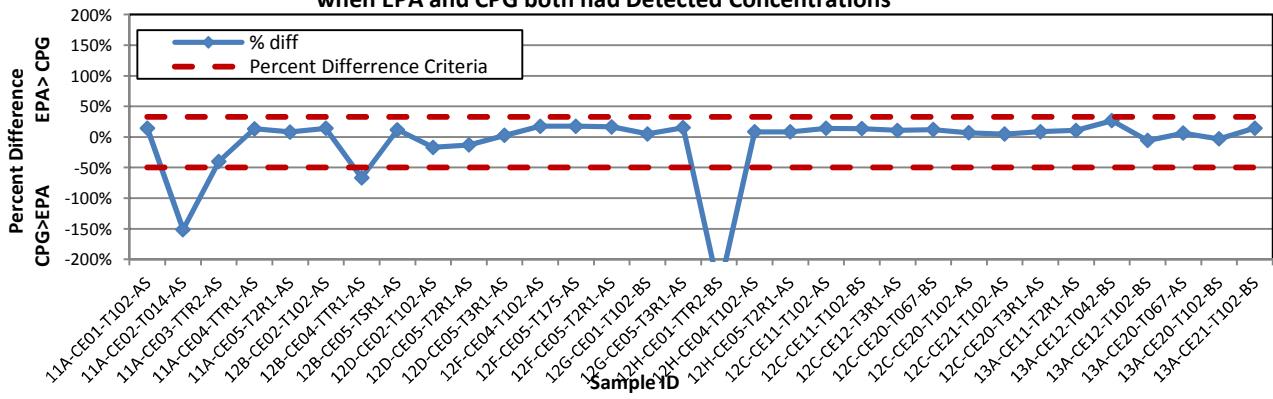


Figure 46c: Line Plot of Total Organic Carbon Percent Differences when EPA and CPG both had Detected Concentrations



Statistical Plots of Total Organic Carbon Concentrations

Figure 46

mg/L - milligram per liter

Figure 47a: Line Plot of Dissolved Organic Carbon Concentrations

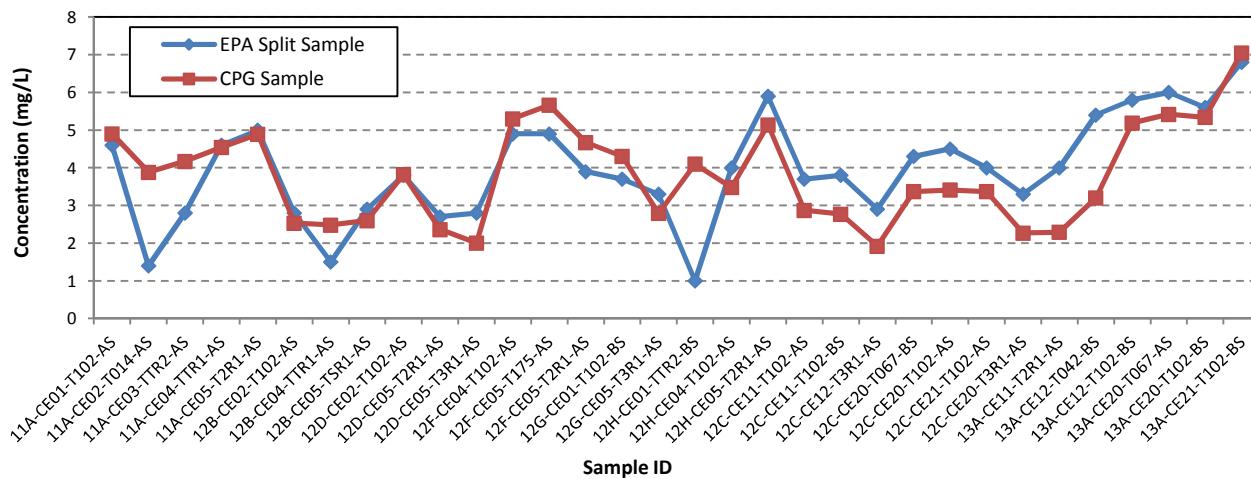


Figure 47b: Bivariate Plot of Dissolved Organic Carbon Concentrations

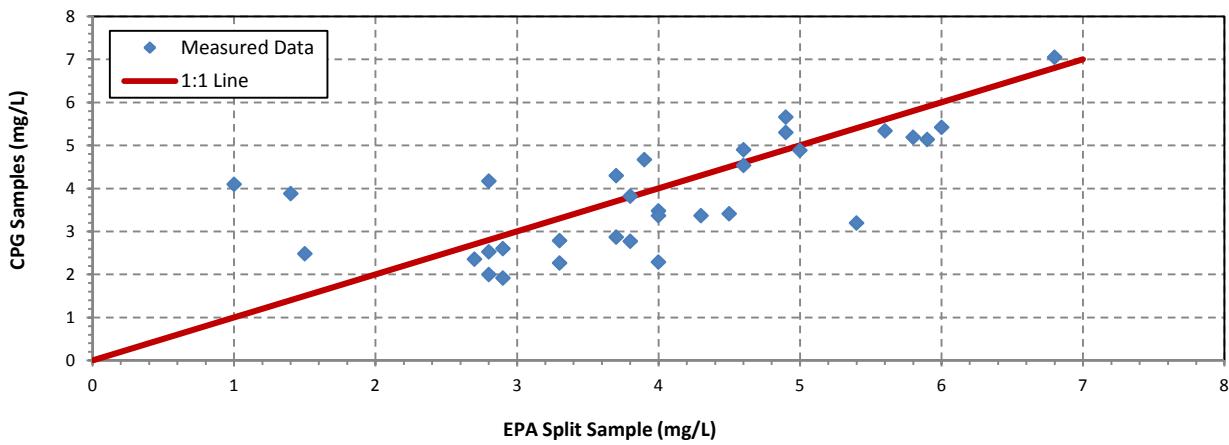


Figure 47c: Line Plot of Dissolved Organic Carbon Percent Differences when EPA and CPG both had Detected Concentrations

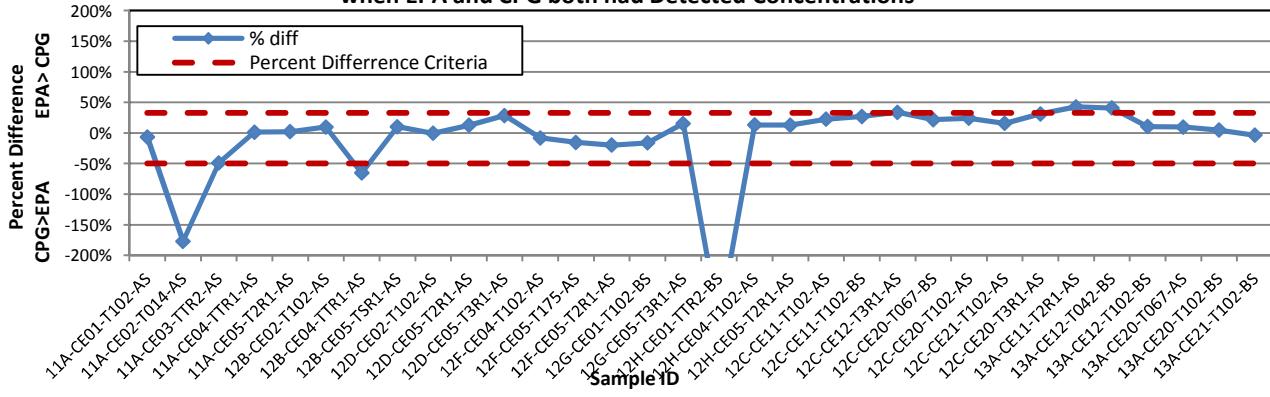


Figure 48a: Line Plot of Particulate Organic Carbon Concentrations

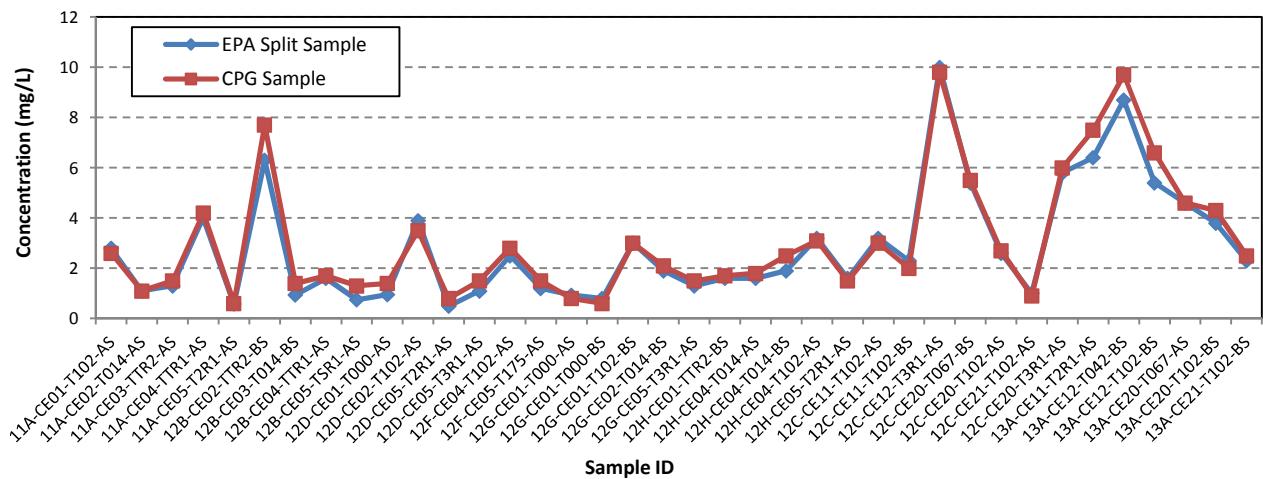


Figure 48b: Bivariate Plot of Particulate Organic Carbon Concentrations

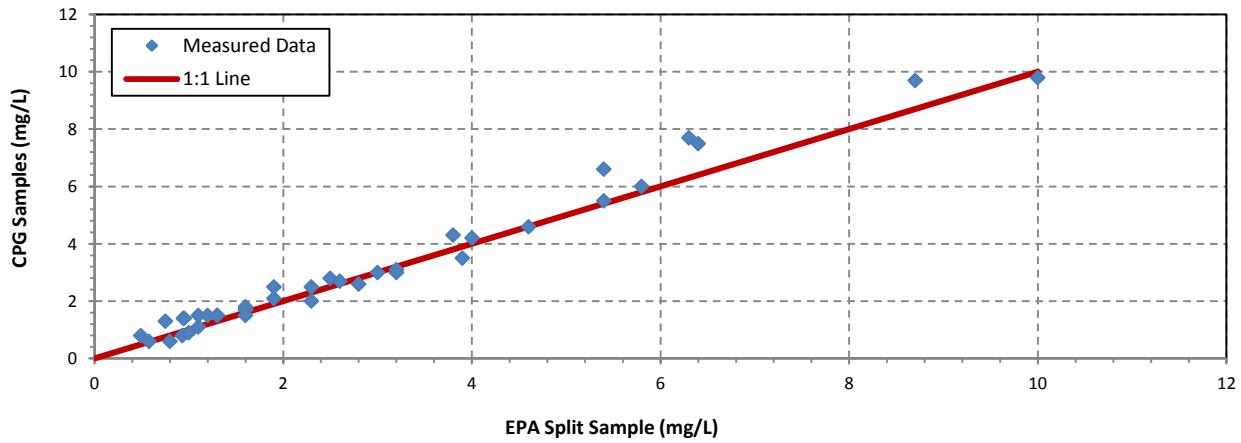


Figure 48c: Line Plot of Particulate Organic Carbon Percent Differences when EPA and CPG both had Detected Concentrations

